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✓ MONTANA DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
HELENA, MONTANA

NOTICE OF RELEASE OF HUNTER GERMPLASM PONDEROSA PINE SELECTED CLASS OF GERMPLASM

The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service), U.S. Department of Agriculture, the Agricultural Experiment Stations of Montana and Wyoming, the USDA Agricultural Research Service, the U.S. Forest Service, and the Montana Department of Natural Resources and Conservation announce the naming and release of selected ecotype of Rocky Mountain ponderosa pine (*Pinus ponderosa* var. *scopulorum* Engelm.). This germplasm was evaluated and selected by the USDA/NRCS Plant Materials Center (PMC) at Bridger, Montana.

As a selected release, this plant will be referred to as Hunter Germplasm ponderosa pine, NRCS accession number 9081843.

Justification for this alternative release procedure is based on a critical need for well-adapted, fast-growing evergreen trees for windbreaks and shelterbelts east of the Continental Divide in the northern Rocky Mountains and Great Plains. A lack of tested and adapted germplasm and the potential use of nonadapted seed sources further supports Selected class release. Additionally, this selection originates from northern Rocky Mountains and Great Plains seed sources that are well adapted to the conditions in the intended geographic area of use. Hunter Germplasm ponderosa pine was selected for its superior height growth, seedling survival, and vigor—primarily for use in windbreaks and shelterbelts. This selection is not recommended for wildland reforestation projects. The use of adapted ecotypes, as defined by seed provenance studies and seed transfer guidelines, may be better suited for wildland timber production at a given location (seed zone).

Collection Site Information: The origin of Hunter Germplasm ponderosa pine is from 38 parent trees' [Nebraska (16 trees), Montana (15), and South Dakota (7)] consisting of 12 provenances* [Nebraska (5 provenances), Montana (6), and South Dakota (1)]. A summary of site information relative to each provenance appears in appendix A. It is assumed that all parent trees are native to the geographic sites in which they were found growing (i.e., not planted seedlings from off-site seed sources).

Hunter Germplasm ponderosa pine is a composite of a 200-tree seed orchard located in Carbon County, Montana, approximately 3 miles south and east of the town of Bridger, at the NRCS Plant Materials Center (see Method of Selection for planting site information).

Description: Hunter Germplasm ponderosa pine has the same general botanical (floral, foliage, fruit, seed) and phenological attributes as the species and variety. When descriptive information is specific to Hunter Germplasm, it is noted as such. It is assumed Hunter Germplasm traits are heritable and that the appearance and performance of the progeny from this selection will be comparable to that of the parents.

Ponderosa pine is a perennial, woody, coniferous (evergreen) tree native to western North America (figure 1) (1). There are currently two varieties of the species recognized, *Pinus ponderosa* var. *ponderosa* (Pacific ponderosa pine) and var. *scopulorum* (Rocky Mountain ponderosa pine). It is currently believed that var. *scopulorum* consists of two major races, the Rocky Mountain race and the Southwestern race. The Rocky Mountain race consists of seed sources from the northeast portion of the species' range (2), including Montana, Wyoming, South Dakota, and Nebraska. Northern sources of this race are characterized by relatively good growth rates and frost resistance (3). All Hunter Germplasm ponderosa pine parent trees are from provenances within the Rocky Mountain race of var. *scopulorum*, and are assumed to be such (figure 2). The Rocky Mountain race is characterized by compact foliage, a predominance of two-needle fascicles (bundles), and superior growth in trials east of its natural range (4). Needle arrangement in Hunter Germplasm varies by individual tree, parent tree, and provenance and includes various percentages of two- and three-needle fascicles. A predominance of two-needle fascicles has not been observed in preliminary examinations of selected trees. Needle length averages approximately 13 cm (5 in), ranging from 8 to 23 cm (3 to 9 in). The leaves are linear (acicular), flexible, and vary in color from dark gray-green to yellow-green. Needles generally persist for three growing seasons.

The species is capable of reaching a height of 70.7 m (232 ft) and attaining a diameter breast high (dbh) of 262.1 cm (103.2 in). Heights of 27 to 40 m (90 to 130 ft) and diameters of 76 to 127 cm (30 to 50 in) are common for this species (5). Rocky Mountain ponderosa pine is considered medium in its rate of growth in the northern Great Plains, attaining an estimated height of 518 cm (17 ft) and crown width of 366 cm (12 ft) in 20 years (6). Mature ponderosa pine crowns average 7.6 to 9.1 m (25 to 30 ft) in width, but can reach 15.2 to 22.9 m (50 to 75 ft) with age. A height growth rate of 30.5 cm (1 ft) per year can be expected at 15 years of age (7). Hunter Germplasm ponderosa pine has an average height of 278.4 cm (9.1 ft) and width of 219.9 cm (7.2 ft) at 10 years of age. The height growth of Hunter Germplasm averages 64.1 cm (25.2 in) per year at 10 years of age. For well-maintained dryland plantings east of the Continental Divide, anticipate a 20-year height and crown width of 762 to 915 cm (25 to 30 ft) and 488 to 549 cm (16 to 18 ft), respectively. Competition over time within a windbreak system will reduce rates of growth; whereas, supplemental irrigation, fertilization, and row spacing will increase growth rates.

Ponderosa pine is monoecious with male (microsporangiate) and female (megasporeangiate) strobili (cones) borne separately on the same tree. Male cones predominate on the basal end of new shoots, mostly on older lateral branches in the lower crown. Female cones are found primarily in the upper crown, usually at the apical end of the main branches in the position of subterminal or lateral buds. With a 2-to 2-year maturation, the growth of new shoots positions developing cones laterally along the stem the second year (8).

¹ - Parent tree is the mother plant from which seed was collected and used to produce test seedlings. Accession and seed source are used synonymously to describe the progeny (seedlings) from a given parent tree.

² - Provenance is a group of parent trees, accessions, or seed sources originating from a given geographic location or stand.

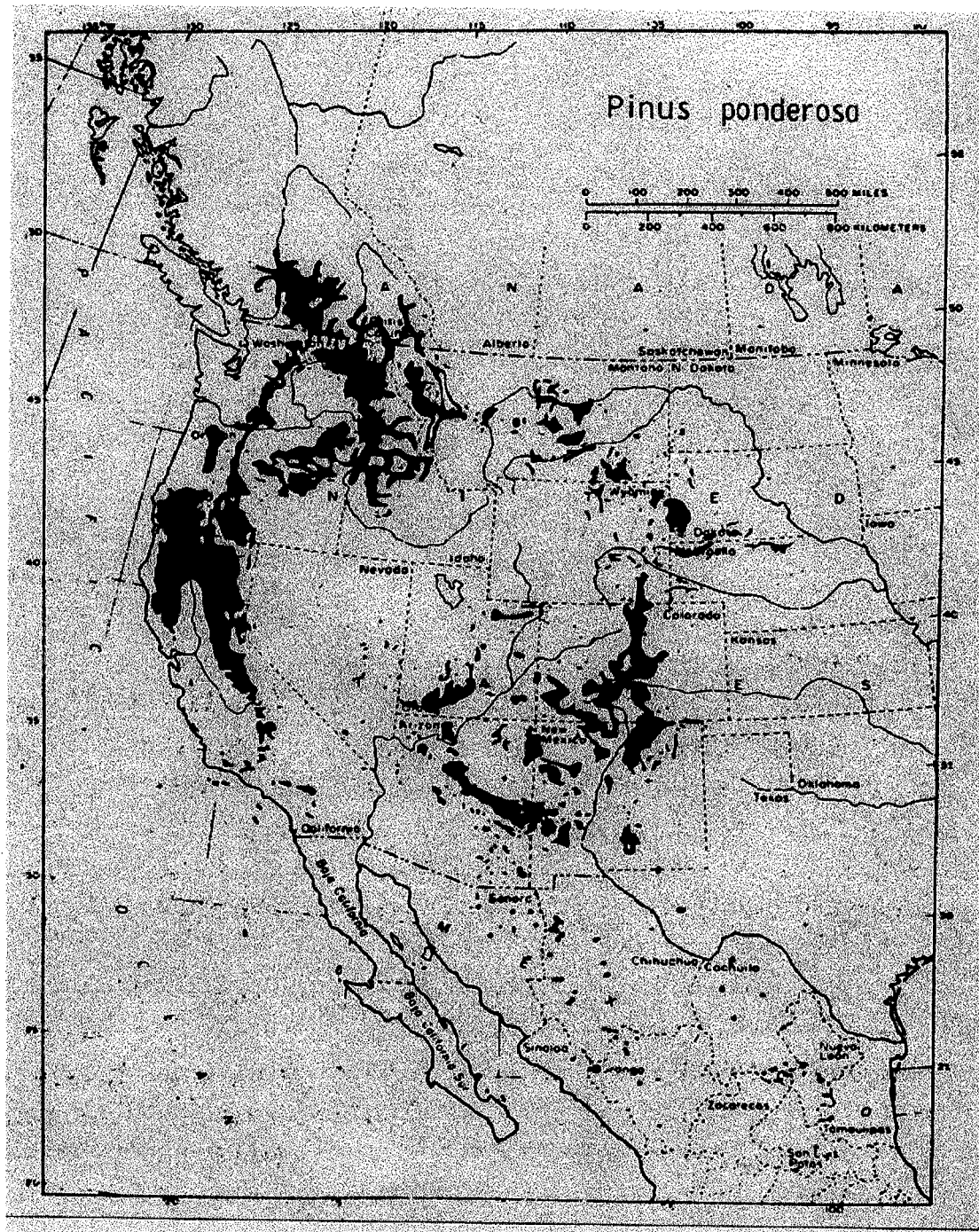


Figure 1. Native range of ponderosa pine *Pinus ponderosa* (1).

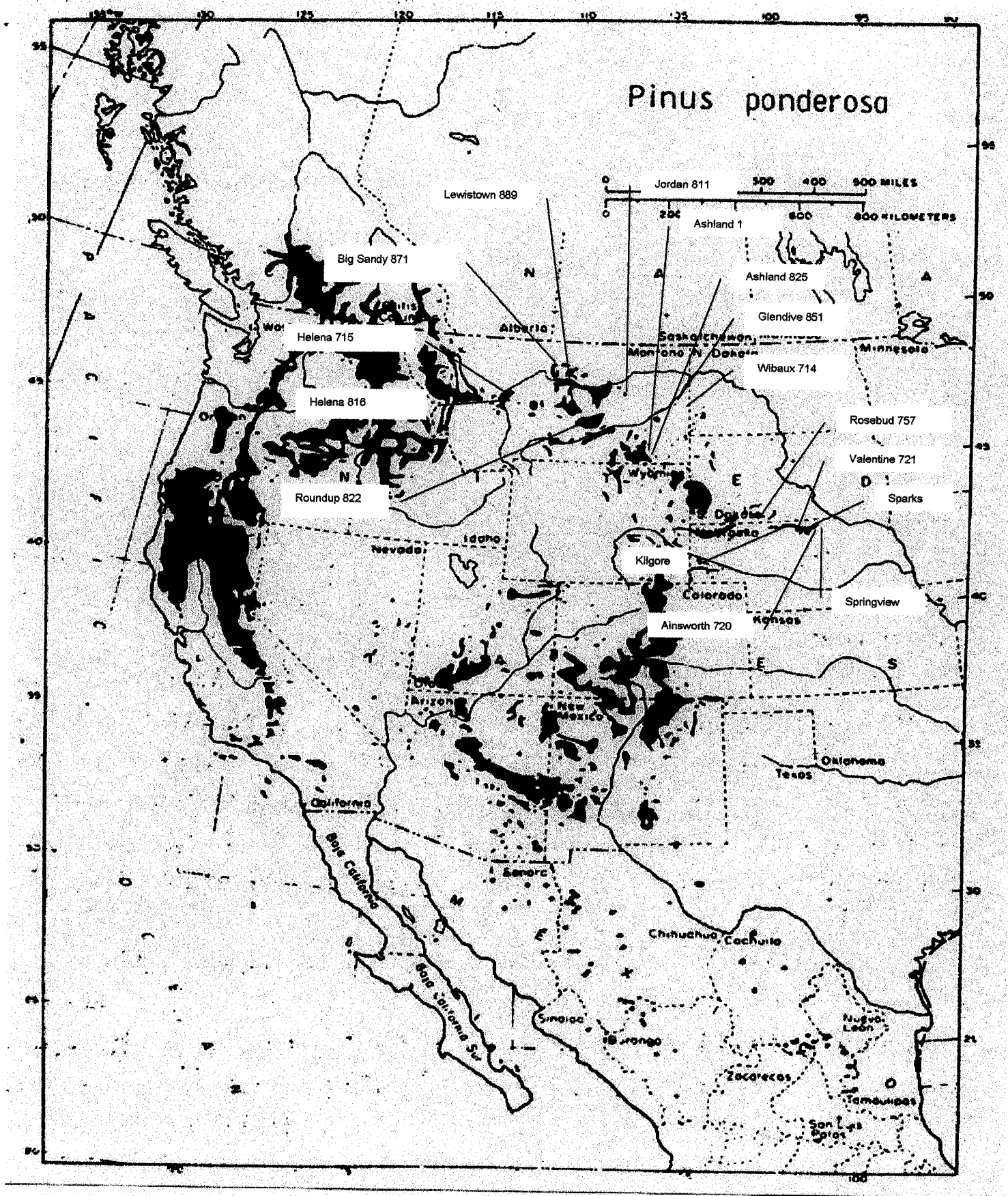


Figure 2. Geographic origin of ponderosa pine provenances tested at Bridger, Montana (1).

As with most members of *Pinus*, male strobili are arranged in indistinct spirals in clusters 1.3 to 5 cm (0.5 to 2.0 in) long (9, 10, 11, 12). Before ripening, male cones of Hunter Germplasm ponderosa pine vary in color from yellow to reddish purple, but are light brown to buff colored at pollen shed, and begin dehiscing soon **after** ripening. Female cones emerge from the winter bud shortly after the male cones and are green or red to purple (9, 12, 13, 14). At pollination they are erect and measure 1 to 3.8 cm (0.4 to 1.5 in) in length. Ponderosa pine is wind pollinated, with pollination **occurring** in late spring or early summer (13). Pollination of Hunter Germplasm¹ in Bridger, Montana, normally occurs in early May. After pollination, scales of the female cones close, and the cone begins a slow development. At the end of the first growing season they are approximately one-eighth to one-fifth the length of mature cones. Fertilization occurs in spring or early summer about 13 months after pollination, and the cones then begin to grow rapidly (8, 15).

Hunter Germplasm ponderosa pine has mature female cones that are 5 to 8 cm (2 to 3 in) in length, with bracts shorter than seed scales and each bearing two seeds at the base of the upper surface. The umbo is dorsal and armed. The cones are ovoid to ellipsoidal in shape, pendent, sessile to the stem, and solitary or clustered in arrangement. Maturation requires 2 years. Hunter Germplasm cones begin ripening in early- to mid-September in Bridger, Montana. They change from a predominantly green or purple color to yellow or light brown upon initial ripening. Cones should be harvested within several days (usually 7 to 10) of initial bract separation to assure maximum seed retention. Flotation tests based on cone specific gravity can also be used to determine cone ripeness. Ripe ponderosa pine cones (specific gravity <0.85) will float in kerosene (specific gravity 0.80) (16). Test only freshly picked cones--excessive drying can lead to false conclusions as to maturity. Avoid collecting cones prematurely in order to optimize cone opening and seed extraction (17, 18). Sample cones to determine seed content and ripeness. A cross section of a mature seed has a firm, white-to-yellow or cream-colored endosperm and a white-to-yellow embryo that fills the endosperm cavity (8). Although some mature cones dehiscence in late fall, most persist until spring or summer of the following year. Dry cones immediately after harvesting to prevent molding or excessive internal heating, which can lead to rapid seed deterioration. Spread cones in a thin layer in a warm, dry location and **allow** them to dry slowly. Hunter Germplasm cones are air dried in a greenhouse maintained at 24 to 27°C (75 to 80°F) days and 16 to 18°C (60 to 65°F) nights for 2 to 3 weeks. Cones that are not fully opened are then placed in a drier at 66°C (150°F) for up to 48 hours. Drying cones of Rocky Mountain ponderosa pine at 74°C (165°F) for 2 hours is recommended by one source (19). Cones that air dry without opening fully may require soaking in water for 12 to 24 hours prior to kiln drying (16). Small lots of dry cones can be shaken by hand in a plastic bucket to remove the seeds from the cones. Large lots are usually processed in a mechanical tumbler or shaker. Seeds can be mechanically de-winged, flailed in a sack, or rubbed by hand. Small lots of seeds can be safely de-winged at low speed (pulsing) in a blender in which the impeller blades have been covered with duct tape. Inspect samples to assure that the seed is not being damaged. Seeds are finished over a fanning (air/screen) mill to remove chaff.

Small quantities of ponderosa pine seed are usually produced each year, with large crops at 3- to 5-year intervals (20). The 200-tree Hunter Germplasm seed orchard produced 11,286 cones and 24.25 kg (53.46 lb) of clean seed from its first seed crop in 1999 (appendix B). Cone production from the 14-year-old trees ranged from 0 to 408 cones per tree with an overall average of 58 cones per tree. Ninety-eight percent of the trees in the seed orchard produced at least one cone. Seed production from the 14-year-old trees ranged from 0 to 499 g (17.6 oz) of seed per tree with an overall average of 125.1 g (4.4 oz) of seed per tree. Hunter Germplasm averages 27,742 seeds per kg (12,595 seeds per pound), ranging from 3,561 seeds per kg (7,577 seeds per lb) to 53,401 seeds per kg (24,244 seeds per lb).

Long-term storage of most pines is at 5 to 10 percent moisture content with temperatures between -18 to -15°C (0 to 5°F) (14, 18). Do not remove seeds from cold storage more than 1 week prior to use (21). Fresh seeds germinate well without cold moist chilling; whereas, stored seeds require 20 to 60 days of stratification at 0.5 to 5°C (33 to 41°F) to break dormancy (18, 22). Presoak seeds in water for 24 to 48 hours and then place them in a moist, well-drained medium prior to cold chilling.

Nursery production of ponderosa pine is best on fertile, well-drained soils. Large nurseries generally fumigate the soil prior to sowing. Nondormant seeds or pretreated dormant seeds may be sown in the

spring. Embryo-dormant seeds can be fall-sown without pretreatment. Fall sowing typically produces a larger and better-developed seedling in 1 year than spring sowing. The amount of seed sown per unit area and the sowing density vary with germination capacity and desired seedling density. The stocking density depends on the choice of nursery practices, including length of time that the seedlings will remain in the nursery bed and whether they will be transplanted (8). Cold stratify seeds (as previously described) in a moist medium prior to spring sowing. Sowing densities should be used that produce 35 to 40 seedlings per square foot. For 2-0 stock, seeds are sown to a depth of 0.3 to 0.6 cm (0.125 to 0.25 in) (23). Place fall-sown seeds slightly deeper [up to 0.6 cm (0.25 in)] than spring-sown seed to protect them from wind erosion and frost action (8).

Ponderosa pine is readily propagated in containers, and survival of outplanted container stock in one test study was significantly higher ($P > .05$) than bareroot stock of the same age (24). Cold, moist stratify stored seeds prior to sowing in a well-drained, peat-lite mix in the greenhouse. Base seeding rate on tetrazolium viability and anticipated germination percentage of each lot in order to produce one seedling per container. Ponderosa pine are typically grown for 2 to 3 years in containers before outplanting. For this production interval, 492- to 655-cm³ (30- to 40-in³) containers are commonly used. Avoid conditions such as undersized containers and long production intervals that can lead to becoming pot- and root-bound seedlings.

Vegetative propagation of ponderosa pine is primarily by grafting. Some limited success with conventional stem-cutting propagation has been achieved using stock plants less than 5 years old (15, 25, 26). In a test of four grafts and budding techniques, no significant difference was found between succulent (mid-June) and dormant (mid-April) scions. Cleft grafts were statistically significantly better than whip, patch, and bottle grafts (27). Grafting represents a valuable method of preserving and propagating older ponderosa pines. Very old trees have been successfully grafted on 3-year-old ponderosa root stock in April under greenhouse and nursery (field) conditions. Success has been achieved with interspecific grafting with several other pine species (28). Limited instances of root formation by air-layering have also been reported (29).

The vegetative buds of Hunter Germplasm ponderosa pine measure approximately 0.63 cm (0.25 in) wide and range in length from 0.63 to 3.8 cm (0.25 to 1.5 in), with an average length of 1.8 cm (0.7 in). Vegetative buds are usually covered with droplets or a crust of resin. The stems (twigs) of ponderosa pine are stout and produce a turpentine odor when bruised (20).

The bark of Hunter Germplasm ponderosa pine varies from grey-brown to dark grey to nearly black in color. The bark is furrowed and scale-like, which is typical of vigorous or young trees of the species. Old and slow-growing ponderosa pine have a yellowish brown to cinnamon-red bark that is broken into large, flat, superficially scaly plates separated by deep, irregular fissures (20).

Young ponderosa pines develop a taproot for anchorage that is supplemented over time by an extensive, moderately deep, wide-spreading lateral root system (20). The ability of seedlings to develop a vigorous taproot is credited, in part, with their ability to establish on difficult sites. Roots can grow to depths of 50 cm (20 in) or more in loosened, moist soil the first year (30). Grass competition does not appear to inhibit root growth when available soil moisture is abundant (31). Expect taproots to grow to a depth of 25 cm (10 in) or less the first year under average field conditions. Lateral roots may double or triple in length each year for the next 2 years (3). Mature ponderosa pine can root to depths of 2 m (6 ft) in porous soils, but seldom reach more than 1 m (3 ft) on heavy soils. In open stands, lateral roots may extend 46 m (150 ft); whereas, in dense stands they are limited to the crown width. The bulk of the root mass is concentrated within the top 60 cm (24 in) of the soil profile (4).

Hunter Germplasm ponderosa pine transplants survive well given proper care and maintenance. The survival of 202, 10-year-old Hunter Germplasm ponderosa pine trees averaging 1.8 to 2.4 m (6 to 8 ft) in height has been 99 percent over the 4-year period since transplanting. The trees were flood irrigated in the fall prior to moving, and transplanted as fully dormant stock in April of the following year using two, 114-cm (45-in) diameter tree spades. Each transplant was immediately guyed, bermed, and irrigated. Irrigation occurred every 2 to 3 weeks over the course of the first growing season after transplanting,

providing approximately 95 l (25 gal) of water per tree per irrigation. As part of the irrigation schedule, a 9-45-15 N-P-K liquid fertilizer was applied three times over the first growing season at a rate of approximately 150 ppm. Growing season irrigation has continued on approximately a monthly basis since the beginning of the second year after transplanting.

Several ponderosa pine attributes make it a particularly good candidate for a medium to large tree component in windbreaks and shelterbelts. Its wide geographic range; cold, heat, and drought tolerance; and ability to withstand a wide range of soil conditions, allows this species to tolerate the diverse environmental conditions of the northern Rocky Mountains and Great Plains. It has low critical levels of foliar nitrogen and phosphorus, allowing it to utilize limited soil fertility on marginal sites, such as mine spoils. In addition, ponderosa pine has several desirable physical characteristics including long, dense, rigid needles, moderate overall density, short stout branches, and slow self-pruning. Also, this is a long-lived tree, capable of reaching ages of 300 to 600 years (4).

Method of Selection: Despite its numerous desirable attributes and the ability to tolerate variable and marginal site conditions, ponderosa pine growth and survival can vary significantly by seed source, limiting its effectiveness in windbreaks and shelterbelts. Numerous provenance tests confirm strong geographic and altitudinal differentiation in this species (3, 15, 32, 32, 34, 35). In addition, a lack of commercially available seed adapted to Plains planting sites may result in the use of cultivated and wildland sources poorly suited to these locations. Also, no genetically improved germplasm of this species is currently available for the production of conservation trees for the northern Rocky Mountains and Great Plains.

Hunter Germplasm ponderosa pine is the product of a ponderosa pine provenance study organized and coordinated by Richard M. Jeffers, Regional Geneticist, Rocky Mountain Forest and Range Experiment Station, Lincoln, Nebraska. The study was conducted in cooperation with the Technical Committee for Improved Trees and Shrubs on the Great Plains (GP-13), a subcommittee of the now defunct Great Plains Agricultural Council (GPAC). The principle objective of the study was to identify Great Plains (east of the Continental Divide) seed sources of ponderosa pine with superior height growth and seedling survival for planting over a wide and diverse range of environmental conditions within the Great Plains. In addition, the Montana Interagency Tree and/or Shrub Improvement Study (MITOSIS) sought to improve the quality, diversity, and performance of conservation seedlings produced by the Montana Conservation Seedling Nursery (MCSN) and commercial nurseries for windbreaks and shelterbelts. To achieve both program goals, data was collected periodically in support of the GP-13 project; however, selections of superior material were made sooner at Bridger and included more and different criteria than planned by project organizers.

In 1986, a ponderosa pine provenance study plan was developed with the following objectives:

- (1) To identify the nature and extent of genetic variation present among selected groups of ponderosa pine from the eastern (east of the Continental Divide) portion of the species range.
- (2) To make selections of superior accessions and individual trees in order to reduce deficiencies of low initial survival and variable height growth.
- (3) To provide Great Plains states with genetically-improved germplasm for the production of superior plant materials for use in various conservation plantings.
- (4) To establish a seed orchard(s) for the production of superior germplasm for use in further selection and breeding studies.

Nomination for testing was based on several attributes including:

- (1) relatively young (40- to 100-year-old), native trees

- (2) above average height and diameter growth
- (3) freedom from serious insect pests
- (4) straight, circular bole with minimal taper
- (5) vigorous crowns with small diameter branches perpendicular to the bole
- (6) lower branch retention
- (7) evidence of current cone production

Nominations for progeny testing at Bridger came from two sources. GP-13 recommendations were based on the 10-year results of earlier ponderosa pine provenance testing. The results indicated that trees from provenances in Ainsworth and Valentine, Nebraska, and Rosebud, South Dakota, had superior overall performance in most plantings in which they were tested (34). In addition, trees from Ashland and Roundup, Montana, performed well above average in more than 80 percent of the provenance test plantings; whereas, trees from Jordan and Helena, Montana, performed well in over half of the field plantings. These sources were also included at Bridger. The MITOSIS nominations included six seed sources from Montana that had not been tested in the GP-13 provenance trials.

Lack of superiority in any single trait was not necessarily a reason for rejection. Cones were collected from GP-13 nominated trees (from original field locations and provenance plantings) in 1983 and 1984 and sent to the Forestry Sciences Lab at Lincoln, Nebraska, or the Montana State Forest Tree Nursery [MSFTN (now the Montana Conservation Seedling Nursery)] at Missoula, Montana, for seed extraction and cleaning. GP-13 seed was stored at the Forestry Sciences Lab; whereas, seed from MITOSIS nominations remained at the MSFTN. Seed from individual GP-13 tree collections made in 1962-1964 and 1983-1984 was sent to the MSFTN in early 1985 for the production of progeny test seedlings. Additional collections of MITOSIS seed were made in 1985 and sent directly to the MSFTN for cleaning and planting. Container seedlings were inspected and inferior seedlings culled prior to progeny test establishment. A total of 13 test sites were planned in Canada and the U.S. Seedlings were produced in 492-cm³ (30-in³) Cone-tainers[®] at the MSFTN and shipped to Bridger in May 1989 as 3-0 stock.

The planting site at Bridger was located at an elevation of 1,128 m (3,700 ft) in a 254- to 330-mm (10- to 13-in) annual precipitation zone. Bridger falls in USDA Winter Hardiness Zone 4b, with annual minimum temperatures of -20 to -25°F (-28.9 to -31.6°C). The site was located in Major Land Resource Area (MLRA) 32, Northern Intermountain Desertic Basin. This classification consists of sites in Montana and Wyoming ranging in elevation from 1,100 to 1,800 m (3,609 to 5,905 ft). The climate averages 125 to 225 mm (4.9 to 8.9 in) of annual precipitation with most precipitation in the spring and fall. Precipitation is low and erratic. The average annual temperature is about 7°C (44.6°F) with an average frost-free period of 120 to 140 days (36).

The planting site slopes gradually from south to north and moderately from east to west. The soils are Heldt Series, Heldt silty clay loam, fine, montmorillonitic, mesic, Ustic, Camborthid, on 4 to 8 percent slopes. The upper 46 cm (18 in) of the profile are characterized as mildly alkaline, whereas the lower 46 to 152 cm (18 to 60 in) are strongly alkaline. These soils are formed in deep alluvium and have moderate shrink-swell potential, but high frost-action potential. Although permeability is slow, these soils are well-drained and runoff is considered medium with only a slight risk of erosion. The mean annual soil temperature is 8.9 to 10.6°C (48 to 51°F) and the frost-free period is 120 to 130 days. This soil falls in the Windbreak Group 1 suitability group, and is characterized by deep, friable, nearly level to steep, well-drained soils on stream terraces and fans. Soils in this group are well suited to caragana (*Caragana arborescens* Lam.), honeysuckle (*Lonicera* spp.), lilac (*Syringa* spp.), chokecherry (*Prunus virginiana* L.), American plum (*Prunus americana* Marsh), skunkbush sumac (*Rhus trilobata* Nutt.), buffaloberry [*Shepherdia argentea* (Pursh) Nutt.], sand cherry [*Prunus pumila* var. *besseyi* (Bailey) Gleason], dogwood (*Cornus sericea* L.), and Russian olive (*Elaeagnus angustifolia* L.) (40). The natural vegetation is mixed mid- and short grasses, forbs, shrubs, and cottonwoods along the streams. The dominant

vegetation in uncultivated areas adjacent to the site includes bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) A. Love], needleandthread (*Hesperosifpa comata* Trin. & Rupr.), prairie junegrass [*Koeleria macrantha* (Ledeb.) J.A.Schultes], big sagebrush [*Artemisia tridentata* ssp. *spiciformis* (Osterhout) Kartesz & Gandhi], ponderosa pine (*Juniperus scopulorum* Sarg.), and limber pine (*Pinus flexilis* James) (38).

Preparation of a **1.2-ha** (3.0-acre) field for the pine planting began in **1988**. The field was summer fallowed in **1988** and then treated with **1.2 l/ha** (1 pint/acre) trifluralin as a pre-emergent herbicide on April **20, 1989**. Twenty-centimeter (8-in) diameter holes were drilled with a power auger just prior to planting. The trees were planted on May **3, 1989**, on **2.8 x 2.8 m** (**9 x 9 ft**) spacing in a Randomized Complete Block (RCB) design with noncontiguous, single-tree plots within blocks. Seven blocks (reps), each containing three rows of **71** positions/row, were established (figure 3). This resulted in **21** rows containing a total of **1,491** plants. Depending on the number of trees available for a given accession,

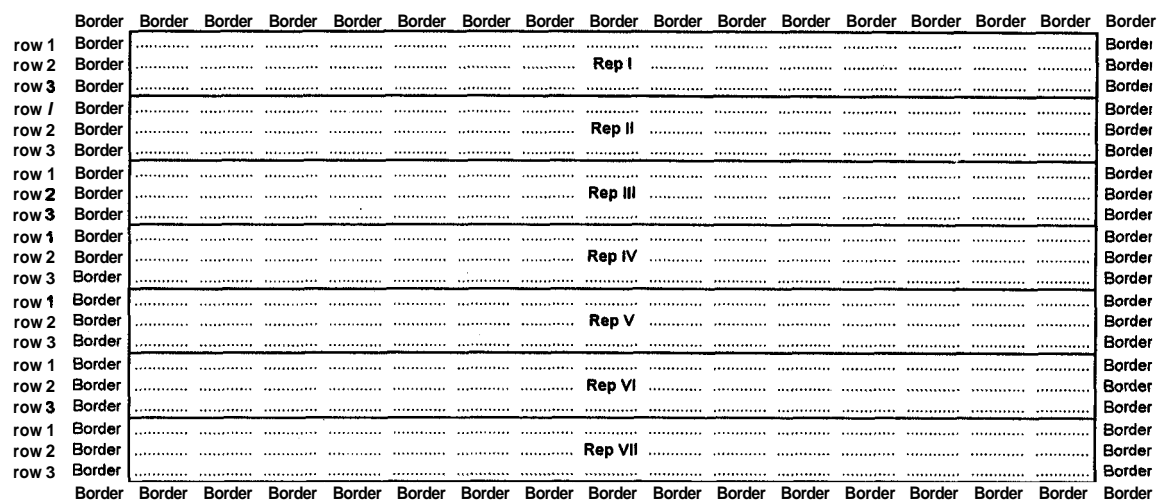


Figure 3. Experimental design, ponderosa pine provenance study, Bridger, Montana.

two to four trees of each collection were planted in each block. Two hundred twenty-five excess test plants were planted in four rows at the south end of the field for use as generic replacements as test plants died. Several common stock trees were also used in the border row. This resulted in the planting of **1,904** test and nontest trees for this study.

Each test seedling was given **3.8 to 7.6 l** (1 to 2 gal) of water at planting time. Protective screens were installed on the south and west sides of each seedling to reduce wind desiccation and sun exposure. Furrows were dug along each row and the entire field was flood irrigated on July **26, 1989**. No supplemental water was applied to the trees until the fall of **1995** when they were given a single flood irrigation in anticipation of seed orchard establishment (transplanting) in spring **1996**. The study was maintained by a combination of mechanical cultivation with a sweep cultivator and spot spraying, primarily for field bindweed (*Convolvulus arvensis* L.) and Canada thistle [*Cirsium arvense* (L.) Scop.]. No supplemental fertilizer was provided until after transplanting in spring **1996**.

Of the 473 RCB³ trees that died in 1989, 146 were replaced with extra test plants held at the south end of the field. In some cases, the same test accession was available and used to replace a dead tree. When a replacement of the same accession was not available, either a different test accession was used or the position was left blank until 1992. In 1992 and 1993, blanks created by dead plants were filled with common stock provided by the MCSN, 418 RCB replacements in 1992 and 9 in 1993. The identification of all replacements was recorded and the aforementioned distinctions made on the evaluation forms. Although data was collected on all replacements, this information was not included in the analyses because of the potential effect of multiple transplanting operations on the performance of these trees.

The study plan for this project called for data collection on survival, total height, diameter (dbh), stem form, branch traits, damage, and flowering at prescribed intervals over the course of the study. Only survival, total height, crown width, and vigor rating were evaluated regularly at Bridger, since these parameters were considered the basis for final selection. Data collection for the Bridger planting was taken more frequently, and, in some cases, earlier than required in the study plan. This was done because it was anticipated that the selection process would begin earlier at Bridger than at the other GP-13 test sites. In addition, the seedlings in the Bridger study were planted on a relatively close spacing, and thinning was desired prior to crown closure between trees. Additional parameters (branch angle, stem and foliage density, form, and color) were included in 1995 to identify ornamental trees during the final selection in 1996.

Field Selection Results

On September 12, 1995, each tree was evaluated and given a rating of "1" if outstanding, "2" if above average, or "3" if average or below. This rating reflected the overall performance and visual appearance of each tree as it grew in the field. Trees receiving a "1" or "2" rating were considered "field-selected" and formed the pool from which final selections were made in 1996. Of the 928 original RCB trees surviving in 1995, 37 trees rated "1" and 292 rated "2" for a total of 329 "field-selected" trees (see [table 1](#); [appendix C](#)). This represented an initial selection level of ~35 percent. Of the 78 remaining accessions in 1995, 67 had at least one member making the preliminary selection. Of the 69 remaining test accessions in 1995, 64 had at least one member making the preliminary selection.

Table 1. Mean 1995 evaluation data according to field selection rating.

Selection Rating [†] (1,2,3)	Number of Trees	1995 Mean Height cm	1995 Mean Vigor Rating [‡] (1-9)	1995 Mean Width cm	1995 Mean Diameter [¶] cm	1995 Mean Branch Angle Rating (1-9)	1995 Mean Density Rating (1-9)	1995 Mean Form Rating (1-9)	1995 Mean Color Rating (1-9)
"1"	37	305.9	2.3	234.7	5.3	4.0	3.5	3.4	3.9
"2"	292	268.1	3.4	210.5	4.1	4.0	3.6	3.7	4.1
"1" & "2"	329	272.3 (+53.0) [§]	3.3 (+1.5)	213.3 (+28.9)	4.3 (+1.4)	4.0 (-0.1)	3.6 (+0.5)	3.7 (+0.9)	4.0 (+0.4)
"3"	599	219.3 (+34.2)	4.8 (+1.0)	184.4 (+18.6)	2.9 (+0.9)	3.9 (0)	4.1 (+0.3)	4.6 (+0.5)	4.4 (+0.3)
RCB trees	928	238.1	4.3	194.7	3.4	4.0	3.9	4.2	4.3

[†] "1" = outstanding, selected; "2" = above average, selected; "3" = average or below, not selected.

[‡] "1" = outstanding; "5" = average; "9" = extremely poor.

[§] () represent performance of all selected trees relative to nonselected trees and to all RCB trees.

[¶] Diameter measured 4.5 feet above ground level.

³ - RCB trees are original test trees excluding common stock (fillers) and border trees. RCB is sometimes used synonymously with "test."

The accessions with the greatest number of trees selected were Valentine **721 #3** and Kilgore **#3** with **12** and **11** trees, respectively. This represents **57** and **73** percent of the surviving trees in each accession, respectively. Springview **#2**, Springview **#3**, and Springview **#9** each had **10** selections representing **67**, **50**, and **48** percent of the surviving trees in each accession, respectively. Ashland **825 #7**, Kilgore **#3**, and Valentine **721 #10** had the greatest number of "1" ratings with three each.

Mean values in **1995** for height, vigor, width, diameter, density, form, and color all demonstrated a positive correlation with field-selection rating. Only branch angle showed a slight inverse relationship with selection rating. Field-selected trees averaged **53 cm (20.9 in)** taller than nonselected trees and **34.2 cm (13.5 in)** taller than all RCB trees. Selected trees averaged **28.9 cm (11.4 in)** wider than nonselected trees and **18.6 cm (7.3 in)** wider than all RCB trees. Similarly, field-selected trees averaged **1.4 cm (0.55 in)** larger diameters than nonselected trees and **1.0 cm (0.4 in)** larger than all RCB trees. Although field-selected trees received superior ratings over nonselected trees in nearly all categories, the greatest gains were in vigor and form with a rating differential of **1.5** and **0.9**, respectively. The greatest rating gains between field-selected trees and all trees were also in vigor and form with a rating differential of **1.0** and **0.5**, respectively.

1995 Evaluation Results

A final evaluation of all test plants was conducted November **14-16, 1995**. The results of this evaluation, in conjunction with the field selection analysis, formed the basis for final selection in **1996**. Evaluation results from **1989** through **1995** are presented to demonstrate long-term trends.

Survival

Seedling losses, number of plants surviving, and percentage survival by accession from **1989** through **1995** appear in appendices D, E, and F, respectively. No RCB plants died after the fall **1994** evaluation. Percentage survival of test accessions ranged from 0 to **100** percent by fall **1995**, with no surviving members of Jordan **811 #1**, and all members surviving in Rosebud **757 #16**, Springview **#3**, Springview **#8**, Springview **#9**, and Valentine **721 #3**⁴. Thirteen additional test accessions had **90** percent or greater survival. The overall mean percentage survival decreased rapidly in **1989** (establishment year) to **68** percent, but was stable from **1991** to **1995** at **62** percent.

Height and Height Growth

Mean height by accession of all RCB plants for **1989** through **1995** appears in appendix G. Mean height of test accessions in **1995** ranged from a low of **169.4 cm (5.6 ft)** for Big Sandy **871 #3** to a high of **287.5 cm (9.4 ft)** for Rosebud **757 #13**. Other top mean heights for test accessions in **1995** include Sparks **#9 (283.1 cm)**, Valentine **721 #4 (272.3 cm)**, Valentine **721 #3 (270.7 cm)**, Sparks **#11 (270.0 cm)**, and Sparks **#2 (267.9 cm)**. The mean height of all RCB plants in **1995** was **238.1 cm (7.8 ft)**.

The overall mean growth rate continued to increase each year up until the last evaluation in **1995** when it reached **55.5 cm (21.8 inches)**. The greatest percentage increase in growth rate occurred in **1991** when the mean growth of all RCB plants averaged a **125** percent increase over the mean growth in **1990**. The lowest percentage increase in growth came in **1993** when RCB plants averaged only a **9** percent increase in growth over the **1992** rate.

Vigor Rating

Mean vigor ratings by accession of all RCB plants for **1990** through **1995** appear in appendix H. Mean vigor of test accessions ranged from a rating low of **5.9** for Big Sandy **871 #3** to a high of **3.2** for

⁴ – Accessions with less than 17 seedlings planted were not considered here.

Kilgore #3. The mean vigor of all RCB plants in 1995 was 4.3. Other top-rated test accessions included Sparks #9 (3.5), Valentine 721 #4 (3.5), Jordan 811 #17 (3.5), Jordan 811 #12 (3.6), and Valentine 721 #3 (3.6). The mean vigor of all RCB plants ranged from a rating low of 4.3 in 1995 to a high of 2.3 in 1989.

Canopy Width

Mean canopy width by accession of all RCB plants for 1993 through 1995 appears in appendix I. Mean north:south widths of test accessions in 1995 ranged from a low of 122.5 cm (4.0 ft) for Big Sandy #3 to a high of 234.3 cm (7.7 ft) for Sparks #8. Other top mean widths for test accessions in 1995 include Springview #2 (233.7 cm), Sparks #9 (231.2 cm), Springview #8 (228.8 cm), Sparks #11 (224.7 cm) and Springview #3 (223.8 cm). The mean north:south width of all RCB plants in 1995 was 194.7 cm (6.4 ft).

Diameter (dbh)

The mean diameter of test accessions ranged from a low of 1.8 cm (0.7 in) for Jordan 811 #4 to a high of 4.8 cm (1.9 in) for Rosebud 757 #13. The mean diameter of all RCB plants in 1995 was 3.4 cm (1.3 in). Other top-rated test accessions include Sparks #9 (4.5 cm), Rosebud 757 #37 (4.4 cm), Ashland 1 #1 (4.2 cm), Valentine 721 #3 (4.2 cm), and Kilgore #3 (4.1 cm).

Branch Angle Rating

The mean branch angle of test accessions ranged from a rating low of 4.4 for Roundup 822 #4 to a rating high of 3.0 for Jordan 811 #17. The mean branch angle rating of all RCB plants in 1995 was 4.0. Other top-rated test accessions include Big Sandy 871 #2 (3.5), Helena 816 #15 (3.5), Jordan 811 #8 (3.5), Jordan 811 #5 (3.6), and Rosebud 757 #13 (3.6).

Density Rating

The mean density of test accessions ranged from a rating low of 5.0 for Rosebud 757 #13 to a rating high of 3.2 for Jordan 811 #14. The mean density rating of all RCB plants in 1995 was 3.9. Other top-rated test accessions include Jordan 811 #21 (3.3), Big Sandy 871 #1 (3.4), Sparks #1 (3.4), Rosebud 757 #16 (3.4), and Jordan 811 #10 (3.5).

Form Rating

The mean form of test accessions ranged from a rating low of 5.5 for Helena 816 #10 to a rating high of 3.0 for Jordan 811 #17. The mean form rating of all RCB plants in 1995 was 4.2. Other top-rated test accessions include Jordan 811 #21 (3.4), Jordan 811 #12 (3.6), Kilgore #1 (3.7), Jordan 811 #20 (3.7), and Jordan 811 #2 (3.7).

Color Rating

The mean color of test accessions ranged from a rating low of 5.1 for Helena 816 #15 to a rating high of 3.8 for Big Sandy 871 #5, Jordan 811 #20, and Jordan 811 #21. The mean color rating of all RCB plants in 1995 was 4.3. Other top-rated test accessions include Big Sandy 871 #2, Ashland 1 #1, and Big Sandy 871 #1, each rated at 3.9.

Final Selections

Final selections were in made on February 20, 1996 by a selection committee consisting of the Plant Materials Specialist, State Staff Forester, Plant Materials Center Manager, and Horticulturist. Final selections were not based on statistically significant differences among trees, accessions, or provenances, but on the selection of the best –20 percent of the surviving population based on mean performance. This was done for several reasons. All accessions were from native, northern Rocky

Mountains and Great Plains sources and most had already proven superior in earlier provenance studies. In addition, the selection committee considered the tested germplasm superior to the common stock being used at the time in plantings east the Continental Divide. These factors, and the broad genetic base of the selection, suggested a strong likelihood of reliable performance. Height growth, percentage survival, and vigor rating determined final selection. The selection process attempted to identify both superior accessions and superior individual trees. Final selections were made on February 20, 1996, based on height growth, seedling survival, and vigor rating. Accession selection generally required performance equal to or greater than the overall population mean for that criteria. A list of orchard selections and corresponding evaluation data appears in appendix J. All trees that rated a "1" in the field selection were automatically included, regardless of the mean height growth, seedling survival, or vigor rating of its respective accession. This resulted in the selection of 37 trees: 26 (70 percent) met all criteria for final selection; whereas, 11 (30 percent) did not meet all criteria. One hundred sixty-seven trees that rated a "2" in the field selection were also chosen. Of these, 169 (82.8 percent) met all criteria for selection, whereas, 24 (14.4 percent) did not meet one criteria. A total of 204 of the 928 surviving RCB trees, or 22 percent, were selected as orchard trees. Thirty-eight of the 79 tested accessions (48.1 percent) had at least one member selected. The 1995 performance of orchard trees relative to non-orchard (non-selected) and all RCB trees appears in table 2.

Table 2. Mean 1995 evaluation data according to final selection status.

Final Selection Status	Number of Trees	1996 Mean Height cm	1996 Mean Vigor Rating* (1-9)	1995 Mean Canopy Width cm	1996 Mean Diameter§ cm	19% Mean Branch Angle Rating (1-9)	1995 Mean Density Rating (1-9)	1996 Mean Form Rating (1-9)	1995 Mean Color Rating (1-9)
orchard	204	278.5 (+51.2) [†]	3.2 (+1.3)	219.9 (+32.2)	4.4 (+1.3)	4.0 (0)	3.6 (+0.4)	3.7 (+0.7)	4.1 (+0.2)
non-orch.	724	227.2 (+40.4)	4.5 (+1.1)	187.7 (+25.2)	3.1 (+1.0)	4.0 (0)	4.0 (+0.3)	4.4 (+0.5)	4.3 (+0.2)
all RCB	928	238.1	4.3	194.7	3.4	4.0	3.9	4.2	4.3

[†] () represent performance of orchard trees relative to non-orchard trees and to all RCB trees.

* "1" = outstanding; "5" = average; "9" = extremely poor.

§ Diameter measured 4.5 feet above ground level.

The height of orchard selections in 1995 ranged from 220 to 360 cm (7.3 to 11.8 ft) with a mean height of 278.5 cm (9.1 ft). The mean height growth of orchard selections and all RCB trees over time appears in chart 1. Projected growth to 20 years of age is also provided. The mean height of orchard selections by accession by year appears in appendix J. The mean height of orchard selections in 1995 was 40.4 cm (15.9 in) taller on average than all RCB trees, an increase in height of 17 percent.

The percentage seedling survival of selected seed sources was 73.3 percent or 17.9 percent greater than the overall population mean (62 percent) and 43.7 percent greater than nonselected seed sources (51 percent). Seedling survival of selected versus nonselected seed sources appears in Chart 2. The percentage seedling survival of selected seed sources is even higher (78.9 percent) if individual trees, selected solely on because they were comparable to the best trees in selected seed sources, are not considered.

Mean Height Growth of Hunter Germplasm Ponderosa Pine

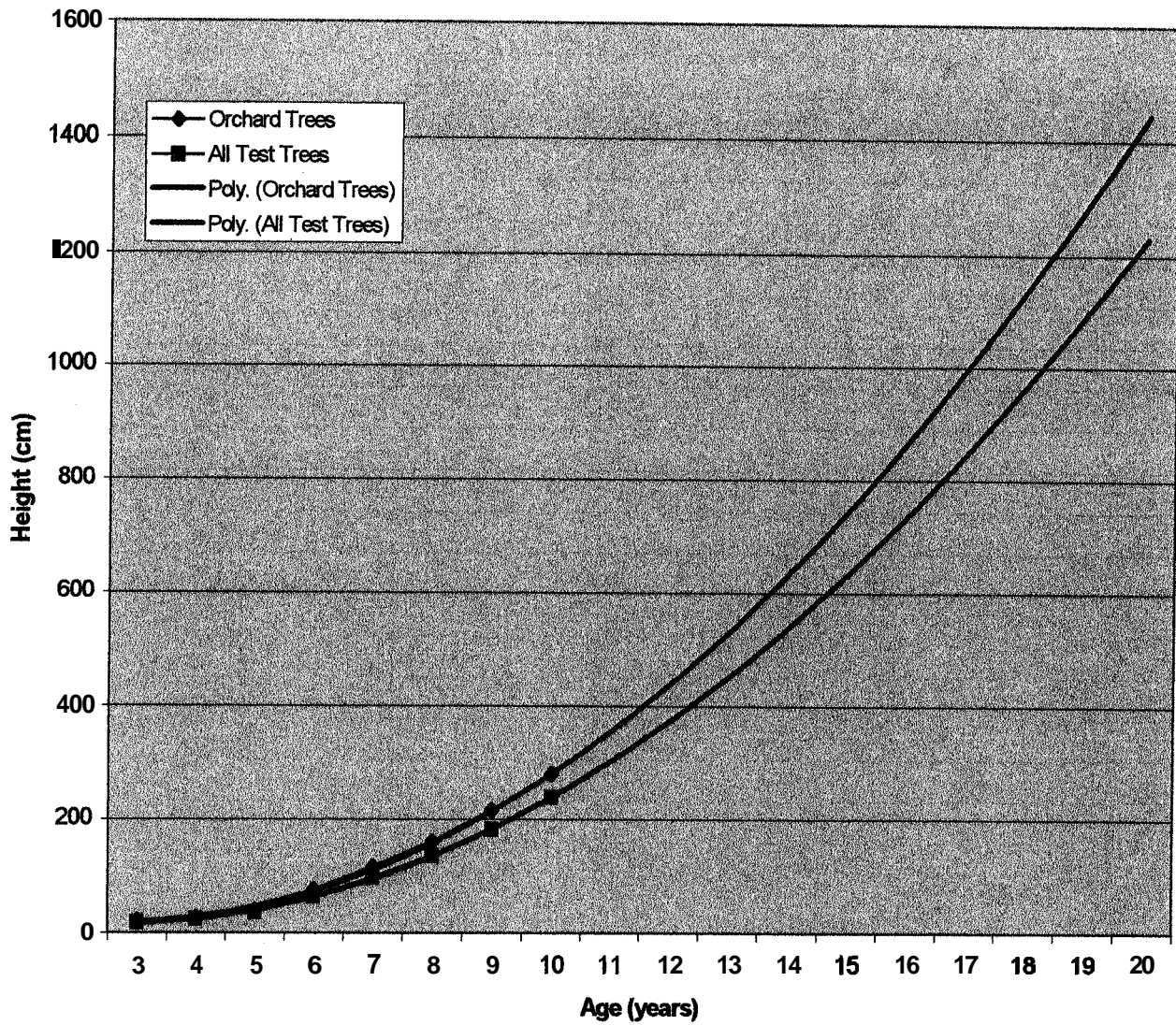


Chart 1. Mean height growth of Hunter Germplasm ponderosa pine (actual and projected).

Seedling Survival (Selected vs Nonselected Seed Sources)

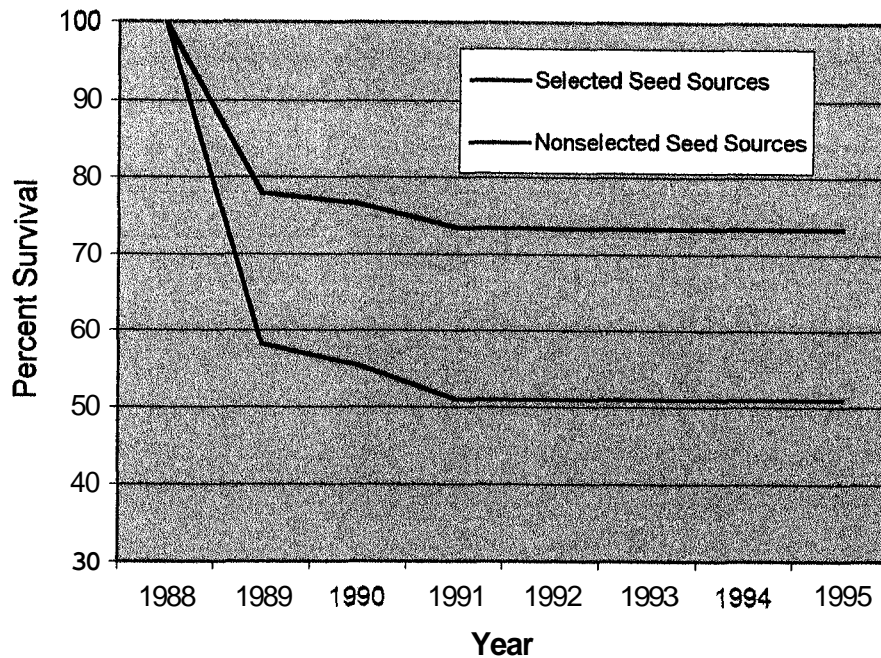


Chart 2. Seedling survival of selected versus nonselected seed sources.

Vigor rating ranged from 5 to 1 with a mean rating of 3.2, 1.1 better than all RCB trees. The north:south canopy width of the orchard trees ranged from 170 to 290 cm (5.6 to 9.5 ft) with a mean width of 219.9 cm (7.2 ft). The mean canopy width of orchard trees was 25.2 cm (9.9 in) greater on average than all RCB trees. This represents an increase in width of 12.9 percent. Trunk diameter ranged from 2.5 to 8.3 cm (1 to 3.3 in) with a mean diameter of 4.4 cm (1.7 in). The mean trunk diameter of orchard trees was 1.0 cm (0.4 in) greater than all RCB trees, an increase of 29.4 percent. The mean branch angle rating of orchard and all RCB trees was 4, ranging from 3 to 5. Branch and foliage density ranged from 2 to 5 with a mean rating of 3.6, 0.3 better than all RCB trees. Form rating ranged from 2 to 6 (plant) with a mean rating of 3.7, 0.5 better than all RCB trees. Color rating ranged from 3 to 5 with a mean rating of 4.1, 0.2 better, on average, than all RCB trees.

The number and percentage of accessions and trees that were planted versus selected appears in table 3 according to provenance.

Table 3. Number and percentage of ponderosa pine final selections by provenance, Bridger PMC.

Provenance	Number of Accessions Planted 1989	Percent of Accessions Planted 1989	Number of Accessions Selected 1995	Percent of Accessions Selected 1995	Number of Trees Planted 1989	Percent of Trees Planted 1989	Number of Trees Selected 1995	Percent of Trees Selected 1995
Ainsworth 720	4	5.1	2	5.3	33	2.2	8	3.9
Ashland 1 #1	1	1.3	1	2.6	21	1.4	1	0.5
Ashland 825	3	3.8	3	7.9	39	2.6	18	8.8
Big Sandy 871	7	8.8	1	2.6	145	9.7	4	2.0
Glendive 851	3	3.8	1	2.6	60	4.0	8	3.9
Helena 715 #1	1	1.3	0	0	5	0.3	0	0
Helena 816	10	12.6	0	0	149	10.0	0	0
Jordan 811	18	22.8	7	18.4	378	25.3	25	12.2
Kilgore	4	5.1	3	7.9	80	5.4	18	8.8
Lewistown 889	1	1.3	0	0	19	1.3	0	0
Rosebud 757	9	11.4	7	18.4	189	12.7	35	17.2
Roundup 822	5	6.3	2	5.3	104	7	9	4.4
Sparks	5	6.3	4	10.5	105	7	23	11.3
Springview	4	5.1	4	10.5	80	5.4	35	17.2
Valentine 721	3	3.8	3	7.9	63	4.2	20	9.8
Wibaux 714	1	1.3	0	0	21	1.4	0	0
Grand Total:	79	100	38	100	1491	100	204	100

The number and percentage of accessions and trees that were planted versus selected appears in table 4 (according to state). It is worth noting the origin of the top seven accessions (top –10 percent of tested accessions) in each evaluation category. For percentage survival, four of the top seven test accessions were from sources in Nebraska (NE), two from Montana (MT), and one from South Dakota (SD). For height, five of the seven top test accessions were from sources in NE, one from MT, and one from SD. For vigor, four of the seven accessions are from NE, two from MT, and one from SD. This pattern continues for canopy width and stem diameter but shifts to a MT-dominated pattern for branch angle, density, form, and color. The superior performance of NE collections is accentuated by their relatively low percentage of accessions and trees planted. The top five most selected test accessions were from sources in NE and two of the three test accessions with the greatest number of “1s” were also from NE.

Table 4. Number and percentage of ponderosa pine final selections by state, Bridger PMC.

State	Number of Accessions Planted 1989	Percent of Accessions Planted 1989	Number of Accessions Selected 1995	Percent of Accessions Selected 1995	Number of Trees Planted 1989	Percent of Trees Planted 1989	Number of Trees Selected 1995	Percent of Trees Selected 1995
Montana	50	63.3	15	39.5	941	63.1	65	31.9
Nebraska	20	25.3	16	42.1	361	24.2	104	51.0
South Dakota	9	11.4	7	18.4	189	12.7	35	17.1
Grand Total:	79	100	38	100	1491	100	204	100

A seed production orchard designed for effective cross-pollination was established at the Bridger Plant Materials Center in 1996 (see [figure 4](#)). The orchard was designed by Lars Halstrom, Forest Geneticist, Gallatin National Forest, Bozeman, Montana. The design isolated related seed sources by at least one tree in all directions. Preparation for orchard establishment began in late 1995 with the flood irrigation of the entire planting. In early 1996, most non-orchard trees were cut down, their stumps removed, and all non-selected plant material burned. During the culling process, two selected trees (Ashland 825 #1 and Valentine 721 #10) were accidentally destroyed. Each new planting location was marked with a wooden stake that identified the current orchard location, as well as the former study location. A similar identification tag was placed on each tree. Two, 114-cm (45-inch) tree spades were used to relocate all orchard trees into their final position. Transplanting began on April 15, 1996, and was completed on April 30. Over this period, approximately 100 non-selected trees that received a "2" in the field selection were moved to windbreak positions on the north and south edges of the Center. All trees were guyed in three directions to prevent movement. Berms were constructed around each tree to act as a catch basin for natural precipitation and supplemental irrigation. The entire orchard was disked and maintained under clean cultivation until 1997. The trees were maintained as previously described (see [Description](#)). On April 24, 1998, 'Covar' sheep fescue (*Festuca ovina*) was seeded as a ground cover. The orchard is sprinkler irrigated periodically to maintain the ground cover and vigor of the orchard trees. The sheep fescue is mowed on approximately 3-week intervals over the course of the growing season. No herbicides have been used to date.

Discussion: Final selection in 1995 was based on height growth and survival, two traits that are critical to successful windbreak establishment and function. These two traits also demonstrate geographic and altitudinal variation. Vigor rating was used as a secondary selection parameter. Final selection at 10 years of age based on height and survival traits are supported by age/age correlations of several studies, both with ponderosa pine and other conifers. Height growth rate at 10 years of age was nearly double that reported for the species under similar conditions. Greater growth rates can be expected with increasing precipitation or supplemental irrigation, fertilization, decreasing elevation, increasing growing season, and other favorable site factors. Survival was similarly improved, approaching 75 percent at the test site--a 10- to 12-inch annual precipitation zone. Concerns regarding inadequate stem development (strength) relative to height growth were mitigated by large percentage gains in diameter (dbh) of selected trees relative to nonselected and all RCB trees. Based on the performance of Hunter Germplasm ponderosa pine in this and earlier studies, this selection should demonstrate good adaptation, as well as excellent productivity.

North

Row 10	Row 9	Row 8	Row 7	Row 6	Row 6	Row 4	Row 3	Row 2	Row 1
Blank	Rosebud 767 #32	Blank	Blank	Blank	Springview#9	Blank	Rosebud 767 #26	Blank	Springview #3
Springview#9	Sparks #2	Springview#2	Posebud 767 #22	Big Sandy 871 #7	lrosebud 767 #16	Jordan 811 #8	Glendive 861 #12	Ashland 826 #7	Sparks #2
Jordan 811 #8	Rosebud 767 #39	Kilgore#3	Ashland 826 #1	Sparks #9	Roundup 822 #2	Springview#2	Sparks #11	Springview #8	Rosebud 767 #32
Ashland 826 #7	Valentine 721 #3	Jordan 811 #15	Springview #3	Rosebud 767 #38	Ashland 826 #7	Valentine 721 #4	Rosebud 767 #22	Roundup 822 #2	Jordan 811 #16
Posebud 767 #32	Springview #3	Sparks #11	Blank	Ainsworth 720 #2	Springview#9	Jordan 811 #10	Springview #9	Ashland 826 #6	Springview #2
Valentine 721 #10	Kilgore #3	Rosebud 767 #26	Jordan 811 #9	Kilgore #1	Glendive 861 #12	Sparks #2	Blank	(Roseb. 767 #38)	Valentine 721 #10
Sparks #9	Ainsworth 720 #11	Ashland 826 #7	Springview #8	Roundup 822 #3	lrosebud 767 #32	Springview #3	Jordan 811 #9	Big Sandy 871 #7	Springview #8
Springview#9	Rosebud 767 #16	Valentine 721 #3	Sparks #11	Jordan 811 #16	Valentine 721 #3	Ainsworth 720 #11	Rosebud 767 #26	Sparks #9	Rosebud 767 #16
Jordan 811 #15	Kilgore #1	Jordan 811 #8	Rosebud 767 #22	Ashland 826 #7	Springview#2	Ashland 826 #1	Valentine 721 #3	Jordan 811 #8	Kilgore #3
Roundup 822 #2	Sparks #2	Glendive 861 #12	Valentine 721 #3	Sparks #9	Kilgore #3	Jordan 811 #9	Kilgore #1	Springview #3	Sparks #2
Posebud 767 #32	Ashland 826 #6	Springview #3	Jordan 811 #9	Springview#9	Valentine 721 #10	Rosebud 767 #16	Sparks #11	Glendive 861 #12	Ainsworth 720 #11
Kilgore #3	Jordan 811 #9	Rosebud 767 #38	Kilgore #3	Big Sandy 871 #7	Ashland 826 #7	Roundup 822 #2	Springview #8	Ashland 826 #7	Rosebud 767 #32
Springview#2	Sparks #11	Ainsworth 720 #11	Roundup 822 #2	Rosebud 767 #26	Jordan 811 #15	Valentine 721 #3	Rosebud 767 #22	Jordan 811 #16	Glendive 861 #12
Ashland 826 #1	Rosebud 767 #16	Jordan 811 #14	Springview #2	Valentine 721 #3	Sparks #2	Springview#2	Ashland 826 #1	Valentine 721 #3	Sparks #11
Springview#3	Roundup 822 #2	Valentine 721 #3	Posebud 767 #32	Ashland 826 #7	Kilgore #3	Rosebud 767 #37	Kilgore #3	Rosebud 767 #16	Springview #2
Sparks #2	Jordan 811 #15	Springview#9	Kilgore #4	Springview#8	Jordan 811 #16	Glendive 861 #12	Springview #9	Sparks #9	Ainsworth 720 #11
Rosebud 767 #22	Big Sandy 871 #7	(Ashland 826 #7)	sparks #8	Ainsworth 720 #11	Posebud 767 #38	Sparks #11	Valentine 721 #10	Ashland 826 #1	Jordan 811 #18
Valentine 721 #10	Springview #8	Rosebud 767 #16	Jordan 811 #8	Valentine 721 #3	Kilgore #1	Springview #3	Roundup 822 #2	Rosebud 767 #26	Springview #9
Jordan 811 #16	Kilgore #3	Roundup 822 #2	Springview #2	Rosebud 767 #26	Sparks #9	Ashland 826 #6	Jordan 811 #15	sparks #2	Valentine 721 #3
Springview#3	Valentine 721 #4	Glendive 861 #12	Ashland 826 #7	Kilgore #3	Valentine 721 #3	Rosebud 767 #32	Ainsworth 720 #2	Springview #2	Kilgore #1
Sparks #2	Rosebud 767 #32	Kilgore #1	Posebud 767 #22	Jordan 811 #9	Springview #3	Glendive 861 #12	Kilgore #3	Jordan 811 #9	Rosebud 767 #16

Figure 4. Seed orchard design, ponderosa pine provenance study, Bridger, Montana.

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Ecological Considerations and Evaluation: Hunter Germplasm ponderosa pine has the same reproductive and establishment characteristics as the species and variety. It is a noninvasive, native species that reproduces only by seed under natural conditions. Numerous natural, evolutionary mechanisms limit the rate and extent of its spread over its intended use area and native range. Natural regeneration is considered sporadic, requiring a combination of heavy seed production and ideal climatic conditions. Initial establishment and spread is often limited by low seed dissemination, inadequate moisture, seed losses to insects and animals, heavy-textured soils, plant competition for moisture and sunlight, low night temperatures, insufficient winter hardiness, frost heaving, and other factors. Losses of established plants occurs from shading, rabbits, hares, squirrels, pocket gophers, porcupines, deer, and domestic livestock (primarily cattle and sheep). Ponderosa pine is the host of numerous insect and disease pathogens. In natural settings, western pine beetle (*Dendroctonus brevicomis*) and several species of *Ips* can be particularly devastating. Dwarf mistletoe (*Arceuthobium campylopodium*) can be a serious disease in native stands whereas Dothistroma blight (*Dothistroma* sp.), needle cast [*Naemacylus* (*Cyclaneusma*) minor], western gall rust [*Endocronartium* (*Peridermium*) *harknessii*], and Diplodia blight (*Diplodia* sp.) have a greater frequency in cultivated plantings (4). Hunter Germplasm ponderosa pine meets all current Plant Materials Program criteria for noninvasiveness.

Caution is advised when grazing livestock in proximity to ponderosa pine. Browsing on needles (fresh and dry), bark, or buds may cause premature birth of stillborn or weak young within 2 to 14 days of ingestion. Abortion can occur in cattle, buffalo, sheep, llamas, and possibly other classes of livestock (39). Mother cow mortality is high if left untreated, presumably from secondary infection and complications. Abortion occurs primarily in the latter stages of pregnancy—often in late fall, winter, and early spring when browse and forage are limited. Animals seldom eat toxic quantities unless there is a lack of other suitable forage (33). Exclusion by fencing, when practical, eliminates this problem. Optimal designs exclude livestock from fallen trees.

Limitations to its geographic use relate to potential planting failures as opposed to negative environmental impacts such as weediness. Depending on the level of care and maintenance, several factors may limit the survival and establishment of ponderosa pine over its intended geographic range of use. In areas of limited summer rainfall, such as southwestern Montana and western Wyoming, lack of available moisture may prevent seedling establishment (1, 41) unless supplemental irrigation is provided. In Montana, east of the Continental Divide, total annual precipitation in ponderosa pine forests ranges from 280 to 430 mm (11 to 17 in), with 125 to 250 mm (5 to 10 in) occurring in the May-to-August period (42). In the Black Hills of South Dakota, average annual precipitation ranges from 410 to 710 mm (16 to 28 in), with up to 330 mm (13 in) occurring from May to August (43).

Natural establishment of ponderosa pine on drier sites is closely related to available soil moisture, which in turn is related to soil texture and depth (5, 44, 45), as well as competing vegetation. On dry sites, coarse textured soils, where limited moisture is more readily available, tend to support ponderosa pine better than fine-textured soils (46). Soil moisture stress resulting from grass and shrub competition can also limit seedling survival and growth (5, 47, 48, 49). Ponderosa pine does not tolerate flooding or soil compaction well.

Other environmental factors that may limit the establishment and growth of ponderosa pine include growing season length (at least 90 days needed in eastern Montana and South Dakota) (42, 50); average minimum winter temperature (below -40°F; USDA Hardiness Zone 3a) (4, 51); and elevational limits of approximately 1,830 m (6,000 ft) in the northern Rocky Mountains (4). This species is sensitive to various airborne pollutants including SO₂, NO_x, HFI, and ozone.

Ponderosa pine is considered shade intolerant, and should be planted in full sun for best performance (4, 51). Locate in windbreak and shelterbelt positions that receive full sun. Design windbreaks and shelterbelts so that there is adequate within- and between-row spacing to prevent shading over time. For all other uses, site plants in locations that receive full sun for most of the day.

Conservation Use: Hunter Germplasm ponderosa pine was selected as a large-tree component in windbreaks and shelterbelts east of the Continental Divide based on superior height growth, percentage

seedling survival, and vigor rating. Its rapid growth allows this selection to reach functional size quickly, thereby providing conservation benefits sooner. Its evergreen foliage provides year-round effect and its moderate branch and foliage density reduces wind speed with minimal turbulence. By reducing wind speed and soil erosion, soil, water, and air quality are improved. Hunter Germplasm ponderosa pine is useful in wildlife habitat enhancement projects providing food, shelter, nesting, and cover for numerous birds and mammals. Hunter Germplasm ponderosa pine is also useful for other conservation practices such as field borders, landscaping, carbon sequestration, logging road revegetation, mined land reclamation, and habitat restoration. Timber, recreation, and esthetic benefits are also gained.

Anticipated Area of Adaptation: The anticipated area of adaptation of Hunter Germplasm ponderosa pine is based on inferences made from the known performance and range of *Pinus ponderosa* var. *scopulorum*. Hunter Germplasm will perform well in most of central, south-central, and southeastern Montana, north-central and northeastern Wyoming, northwestern and north-central Nebraska, and south-central and southwestern South Dakota (figure 5). This selection will probably perform well east of the Continental Divide in most of Montana and eastern Wyoming at elevations below 1,676 m (5,500 ft), possibly 1,830 m (6,000 ft), given other favorable site conditions.

Ponderosa pine grows on a variety of soil types including igneous, metamorphic, and sedimentary. Over its natural range, it grows on Entisols, Inceptisols, Mollisols, Alfisols, and Utisols (4). It does best on coarse-textured soils when available soil moisture is limited (46). Root development of ponderosa pine was greatest on medium-textured soils in Montana in one study (44). Ponderosa pine is seldom found growing naturally on heavy-textured soils with a high clay and/or silt content. The soil pH where ponderosa pine naturally occurs ranges from 4.9 to 9.1 depending on location and soil horizon, but the surface horizon usually ranges from 6.0 to 7.0 (5).

Hunter Germplasm ponderosa pine will grow well in USDA Winter Hardiness Zone 3b, tolerating average minimum winter temperatures of -34 to -37°C (-30 to -35°F). Based on the maximum cold tolerance of the species (4, 51), Hunter Germplasm may tolerate Zone 3a [-37 to -40°C (-35 to -40°F)].

Hunter Germplasm ponderosa pine is recommended in Montana for Conservation Tree and Shrub Suitability Groups 1, 3, 4, 5, 6, 7, and 8 (52). It is not recommended for excessively wet, poorly drained sites, heavily saline or sodic soils, or soils classified as "unsuitable" for tree and shrub planting. Hunter Germplasm ponderosa pine is recommended for Montana Plant Adaptation Zones c, d, f, g, h, i, and j. Seed sources originating from west of the Continental Divide are recommended for Montana Plant Adaptation Zones a and b (6). It is adapted in Montana to sites in Major Land Resource Areas (MLRAs) 32 (Northern Intermountain Desertic Basins), 43 (Northern Rocky Mountains), 44 (Northern Rocky Mountain Valleys), 46 (Northern Rocky Mountain Foothills), 52 (Brown Glaciated Plain), 53A (Northern Dark Brown Glaciated Plain), 54 (Rolling Soft Shale Plain), 58A (Northern Rolling High Plains, Northern Part), and 60B (Pierre Shale Plains, Northern Part) (36). Hunter Germplasm ponderosa pine is currently not recommended for the western half of MLRA 52 (Montana Plant Adaptation Zone e) based on the poor survival of the species in this area, possibly due to Chinook winds or winter desiccation (53).

Hunter Germplasm ponderosa pine has soil salinity tolerances comparable to the species. The soil salinity tolerance of ponderosa pine is generally described as "fair" (6) to "moderately high" (54). The species grows well on sites measuring less than 4 mmhos/cm of electrical conductivity, although it may tolerate 6 mmhos/cm (55). One reference even lists ponderosa pine tolerant to 9 mmhos/cm of electrical conductivity (56). In no case is any indication of plant performance, other than survival, given. Anticipate decreasing growth rates and vigor with increasing salinity above 4 to 6 mmhos/cm.

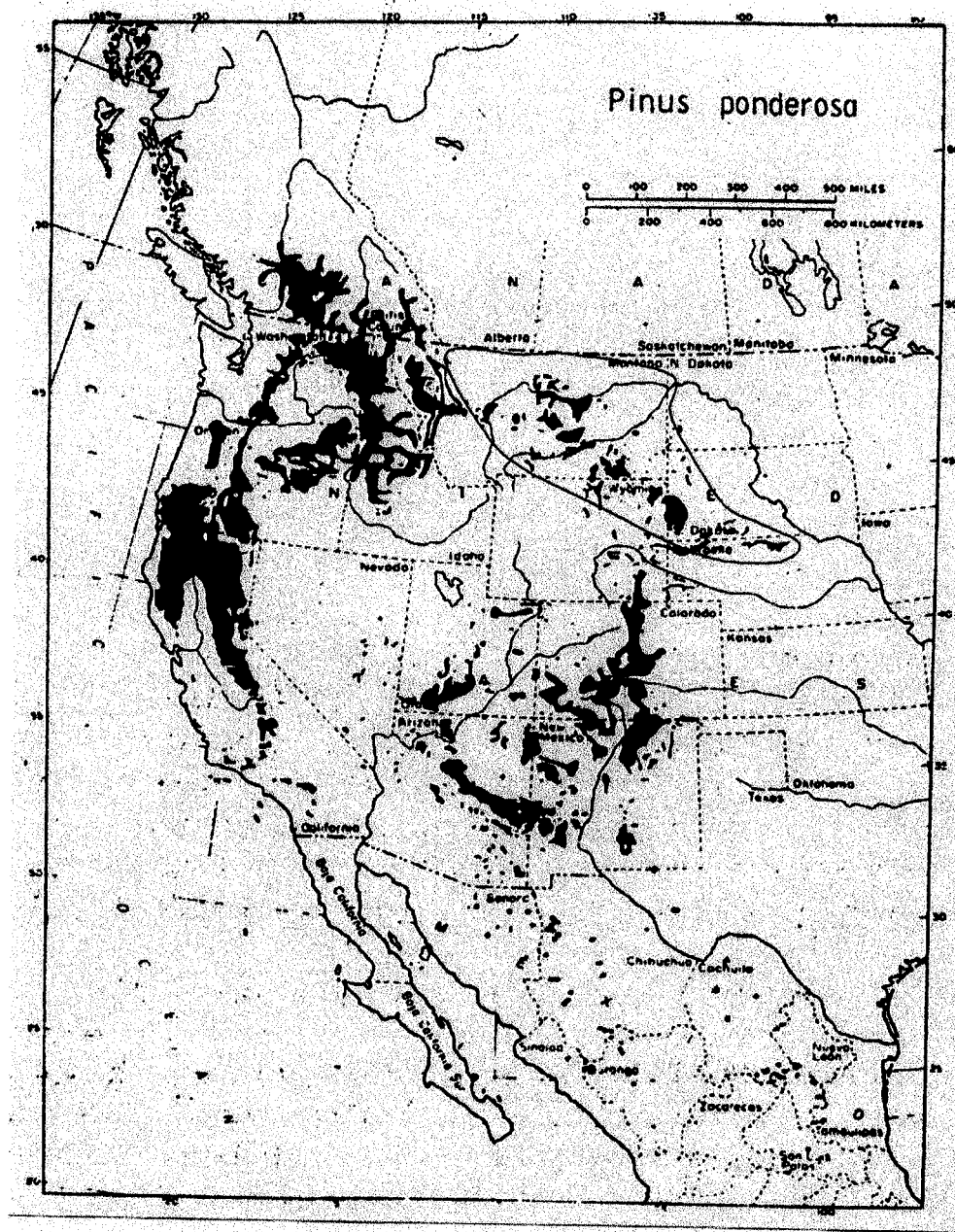


Figure 5. Anticipated area of adaptation of Hunter Germplasm *ponderosa* pine (I-amended).

Availability of Plant Materials: The Bridger PMC maintains Foundation (G1) seed of Hunter Germplasm ponderosa pine for plant production purposes. Foundation seed is distributed through the Montana State University-Bozeman Seed Stocks Program. Grafting scions are available for the establishment of GO seed orchards. For more information, contact the Plant Materials Specialist or Bridger PMC.

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Appendix A. Parent tree record information, ponderosa pine provenance study, Bridger, MT.

Parent Tree (Provenance) Identification	County	State	Nomin. Source	MLRA	Lat.	Long.	Elevation	Annual Precip.	USDA Winter Hardin.
							<i>ft</i>	<i>in</i>	
Ainsworth 720	Brown	NE	GP-13	65/66	42.7	99.8	2,300	20.3	5a
Ashland 1	Powder River	MT	MITOSIS	58A	45.7	106.0	3,600	15.1	4a
Ashland 825	Powder River	MT	GP-13	58A	45.7	106.0	3,600	15.1	4a
Big Sandy 871	Chouteau	MT	MITOSIS	52	48.3	110.5	2,900	12.0	3b
Glendive 851	Dawson	MT	MITOSIS	58A	46.9	105.2	2,650	12.7	3b
Helena 715	Lewis and Clark	MT	MITOSIS	43	46.6	111.8	4,500	10.8	4a
Helena 816	Lewis and Clark	MT	GP-13	43	46.6	111.8	4,500	10.8	4a
Jordan 811	Garfield	MT	GP-13	58A	47.6	106.9	2,900	12.9	3b
Kilgore	Cherry	NE	GP-13	65	†	†	†	†	4a-4b
Lewistown 889	Fergus	MT	MITOSIS	46	47.0	109.6	4,100	17.0	4a
Rosebud 757	Todd	SD	GP-13	66	43.2	101.0	2,600	18.8	4b
Roundup 822	Musselshell	MT	GP-13	58A	46.2	108.4	3,800	10.9	4a
Sparks	Cherry	NE	GP-13	66	†	†	†	†	4b
Springview	Keyapaha	NE	GP-13	66	†	†	†	†	5a
Valentine 721	Cherry	NE	GP-13	65/66	42.9	100.6	2,700	17.3	4a-4b
Wibaux 714	Wibaux	MT	MITOSIS	54	46.9	104.1	2,760	14.0	4a

† - Data unavailable.

Appendix B. Mean cone and seed evaluation data, Hunter Germplasm ponderosa pine, Bridger PMC, 1999.

Seed Source	Mean No. of Cones Harvest.	Mean Amt. of Seed Harvest.	Mean Weight of 100 Seed	Mean Seeds per Pound	Mean Seeds per Kilogram
		g	g		
Ainsworth 720 #11 Average	29.0	40.8	3.7897	13043	28730
Ainsworth 720 #2 Average	126.0	280.0	3.2062	15991	35222
Ashland 1 #1 Average	21.0	43.0	2.8984	15664	34502
Ashland 825 #1 Average	36.3	77.5	3.8423	12149	26759
Ashland 825 #6 Average	99.3	270.0	3.5049	14637	32239
Ashland 825 #7 Average	31.3	79.5	3.9632	11575	25496
Big Sandy 871 #7 Average	47.0	111.3	4.9945	9206	20278
Glendive 851 #12 Average	61.9	146.1	4.2998	10805	23799
Jordan 811 #14 Average	19.0	45.0	4.4216	10268	22616
Jordan 811 #15 Average	58.0	92.6	4.4837	10198	22462
Jordan 811 #16 Average	43.3	86.8	3.3866	14020	30881
Jordan 811 #18 Average	87.0	150.0	3.1174	14563	32078
Jordan 811 #8 Average	37.2	83.2	4.6049	9986	21996
Jordan 81 #9 Average	26.9	60.4	4.1740	11018	24269
Kilgore #1 Average	94.3	193.8	4.0102	11766	25916
Kilgore #3 Average	66.1	138.1	3.6869	13271	29232
Kilgore #4 Average	54.0	85.0	2.9402	15441	34011
Rosebud 757 #16 Average	56.3	85.8	4.1052	11142	24542
Rosebud 757 #22 Average	36.5	92.0	4.4166	11170	24603
Rosebud 757 #26 Average	39.3	79.5	3.7644	12573	27693
Rosebud 757 #32 Average	30.6	75.5	4.3691	10834	23864
Rosebud 757 #37 Average	48.0	263.0	4.4468	10210	22488
Rosebud 757 #38 Average	73.0	135.5	3.8859	11800	25991
Rosebud 757 #39 Average	21.0	51.0	3.5876	12655	27874
Roundup 822 #2 Average	68.9	181.6	3.9857	11712	25798
Roundup 822 #3 Average	3.0	1.0	4.9312[†]	9207	20279
Sparks #11 Average	77.0	159.3	3.9104	11883	26175
Sparks #2 Average	80.8	177.4	4.3099	10773	23730
Sparks #8 Average	2.0	12.0	5.9918	7577	16689
Sparks #9 Average	77.5	201.2	4.2127	10954	24128
Springview #2 Average	114.9	218.9	3.4352	13477	29684
Springview #3 Average	80.2	159.5	3.8557	12653	27871
Springview #8 Average	13.0	32.5	3.4977[†]	13414	29546
Springview #9 Average	27.5	46.6	3.8708	12056	26554
Valentine 721 #10 Average	53.2	114.0	3.7431	12482	27494
Valentine 721 #3 Average	61.0	138.5	3.3834	13968	30766
Valentine 721 #4 Average	105.5	221.0	3.1682	16608	36582
Grand Average [†]	58.2	125.1	3.9437	12095	26641

[†] - Unweighted means

* - Bolded values corrected for trees with less than 100 seed.

Appendix C. Seed orchard selections, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Number of		Comments
	Orchard Trees Originally Selected	Number of Orchard Trees After Losses	
(Ashland 826 #7)R-90	1	1	
(Rosebud 767 #32)R-90	1	1	
(Rosebud 767 #38)R-90	1	1	
Ainsworth 720 #11	6	6	
Ainsworth 720 #2	2	2	
Ashland 1 #1	1	1	
Ashland 826 #1	5	4	one cut
Ashland 826 #6	3	3	
Ashland 826 #7	9	9	
Big Sandy 871 #7	4	4	
Glendive 861 #12	8	8	
Jordan 811 #10	1	1	
Jordan 811 #14	1	1	
Jordan 811 #15	6	5	
Jordan 811 #16	6	4	one died
Jordan 811 #18	1	1	
Jordan 811 #8	5	6	
Jordan 811 #9	7	7	
Kilgore #1	6	6	
Kilgore #3	11	11	
Kilgore #4	1	1	
Rosebud 767 #16	8	7	one died
Rosebud 767 #22	6	6	
Rosebud 767 #26	6	6	
Rosebud 767 #32	8	8	
Rosebud 767 #37	1	1	
Rosebud 767 #38	3	3	
Rosebud 767 #39	1	1	
Roundup 822 #2	8	8	
Roundup 822 #3	1	1	
Sparks #11	7	7	
Sparks #2	9	9	
Sparks #8	1	1	
Sparks #9	6	6	
Springview #2	10	10	
Springview #3	10	10	
Springview #8	6	6	
Springview #9	10	10	
Valentine 721 #10	6	5	one cut
Valentine 721 #3	12	12	
Valentine 721 #4	2	2	
Grand Total	204	200	

Appendix D. Number of RCB losses by accession by Year, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Origin	Accession Number	1989 Number Planted RCB	1989 RCB Losses	1990 RCB Losses	1991 RCB Losses	1992 RCB Losses	1993 RCB Losses	1994 RCB Losses	1995 RCB Losses	1989-1995 Total RCB Losses	1995 Total No. of Trees Surviving
Ainsworth 720 #1	Ainsworth, NE	9063585	21	6	0	0	0	0	0	0	6	15
Ainsworth 720 #2†	Ainsworth, NE	9063622	9	0	0	1	0	1	0	0	2	7
Ainsworth 720 #5	Ainsworth, NE	9063623	2	0	0	0	0	0	0	0	0	2
Ainsworth 720 #8	Ainsworth, NE	9063624	1	0	0	0	0	0	0	0	0	1
Ashland 1 #1	Ashland, MT	9063609	21	11	0	0	0	0	0	0	11	10
Ashland 826 #1	Ashland, MT	9063620	10	3	0	0	0	0	0	0	3	7
Ashland 825 #6	Ashland, MT	9063621	8	0	0	0	0	0	0	0	0	8
Ashland 825 #7	Ashland, MT	9063575	21	3	0	0	0	0	0	0	3	18
Big Sandy 871 #1	Big Sandy, MT	9063602	19	9	1	0	0	0	0	0	10	9
Big Sandy 871 #2	Big Sandy, MT	9063603	21	12	1	0	0	0	0	0	13	8
Big Sandy 871 #3	Big Sandy, MT	9063604	21	9	3	1	0	0	0	0	13	8
Big Sandy 871 #4	Big Sandy, MT	9063605	21	2	0	0	0	0	0	0	2	19
Big Sandy 871 #5	Big Sandy, MT	9063606	21	16	1	0	0	0	0	0	17	4
Big Sandy 871 #6	Big Sandy, MT	9063607	21	9	0	0	0	0	0	0	9	12
Big Sandy 871 #7	Big Sandy, MT	9063608	21	7	0	0	0	0	0	0	7	14
Glendive 851 #11	Glendive, MT	9063612	21	1	0	0	0	0	0	0	1	20
Glendive 851 #12	Glendive, MT	9063613	19	1	0	0	0	0	0	0	1	18
Glendive 851 #13	Glendive, MT	9063614	20	3	2	1	0	0	0	0	6	14
Helena 715 #1	Helena, MT	9063626	5	1	0	1	0	0	0	0	2	3
Helena 816 #1	Helena, MT	9063563	21	12	0	1	0	0	0	0	13	8
Helena 816 #10	Helena, MT	9063568	21	14	0	1	0	0	0	0	15	6
Helena 816 #13	Helena, MT	9063617	1	0	0	0	0	0	0	0	0	1
Helena 816 #14	Helena, MT	9063618	1	0	0	0	0	0	0	0	0	1
Helena 816 #15	Helena, MT	9063569	21	2	0	8	0	0	0	0	10	11
Helena 816 #2	Helena, MT	9063564	21	8	0	5	0	0	0	0	13	8
Helena 816 #3	Helena, MT	9063565	20	15	0	2	0	0	0	0	17	3
Helena 816 #5	Helena, MT	9063566	20	9	0	4	0	0	0	0	13	7
Helena 816 #7	Helena, MT	9063615	2	0	0	0	0	0	0	0	0	2
Helena 816 #9	Helena, MT	9063567	21	7	0	4	0	0	0	0	11	10
Jordan 81 #1	Jordan, MT	9063545	21	20	1	0	0	0	0	0	21	0
Jordan 811 #10	Jordan, MT	9063551	21	2	0	0	0	0	0	0	2	19
Jordan 811 #12	Jordan, MT	9063552	21	16	0	0	0	0	0	0	16	5
Jordan 811 #13	Jordan, MT	9063553	21	10	1	0	0	0	0	0	11	10
Jordan 811 #14	Jordan, MT	9063554	21	10	0	0	0	0	0	0	10	11
Jordan 811 #15	Jordan, MT	9063555	21	4	0	3	0	0	0	0	7	14
Jordan 811 #16	Jordan, MT	9063556	21	5	0	2	0	0	0	0	7	14
Jordan 811 #17	Jordan, MT	9063557	21	18	1	0	0	0	0	0	19	2
Jordan 811 #18	Jordan, MT	9063558	21	2	0	1	0	0	0	0	3	18
Jordan 811 #19	Jordan, MT	9063559	21	8	1	0	0	0	0	0	9	12
Jordan 811 #2	Jordan, MT	9063546	21	0	1	0	0	0	0	0	1	20
Jordan 811 #20	Jordan, MT	9063560	21	11	0	0	0	0	0	0	11	10
Jordan 811 #21	Jordan, MT	9063561	21	3	0	0	0	0	0	0	3	18
Jordan 811 #22	Jordan, MT	9063562	21	17	0	0	0	0	0	0	17	4
Jordan 811 #4	Jordan, MT	9063547	21	1	0	2	0	0	0	0	3	18
Jordan 811 #5	Jordan, MT	9063548	21	3	0	0	0	0	0	0	3	18
Jordan 811 #8	Jordan, MT	9063549	21	7	0	0	0	0	0	0	7	14
Jordan 811 #9	Jordan, MT	9063550	21	2	0	0	0	0	0	0	2	19
Kilgore #1	Kilgore, NE	9063593	17	1	0	0	0	0	0	0	1	16
Kilgore #2	Kilgore, NE	9063594	21	14	4	0	0	0	0	0	18	3
Kilgore #3	Kilgore, NE	9063595	21	5	0	1	0	0	0	0	6	15
Kilgore #4	Kilgore, NE	9063596	21	0	1	3	0	0	0	0	4	17
Lewistown 889 #1	Lewistown, MT	9063611	19	0	0	1	0	0	0	0	1	18
Rosebud 757 #13	Rosebud, SD	9063576	21	11	0	0	0	0	0	0	11	10
Rosebud 757 #14	Rosebud, SD	9063577	21	13	0	0	0	0	0	0	13	8
Rosebud 757 #16	Rosebud, SD	9063578	21	0	0	0	0	0	0	0	0	21
Rosebud 757 #22	Rosebud, SD	9063579	21	2	2	2	0	0	0	0	6	15
Rosebud 757 #26	Rosebud, SD	9063580	20	6	1	1	0	0	0	0	8	12
Rosebud 757 #32	Rosebud, SD	9063581	22	4	1	2	0	0	0	0	7	15
Rosebud 757 #37	Rosebud, SD	9063582	21	16	1	1	0	0	0	0	18	3

† - Accessions with less than 17 seedlings are noted in bold.

Appendix D. Number of RCB losses by accession by year, ponderosa pine provenance study, Bridger, Montana (continued).

Seed Source	Origin	Accession Number	1989	1989	1990	1991	1992	1993	1994	1995	1989-1995	1995
			Number Planted RCB	RCB Losses	RCB Losses	RCB Losses	RCB Losses	RCB Losses	RCB Losses	RCB Losses	Total RCB Losses	Total No. of Trees Surviving
Rosebud 757 #38	Rosebud, SD	9063583	21	7	0	1	0	0	0	0	8	13
Rosebud 757 #39	Rosebud, SD	9063584	21	12	2	0	0	0	0	0	14	7
Roundup 822 #11	Roundup, MT	9063574	21	1	0	1	0	0	0	0	2	19
Roundup 822 #2	Roundup, MT	9063570	21	1	0	1	0	0	0	0	2	19
Roundup 822 #3	Roundup, MT	9063571	21	8	1	2	0	0	0	0	11	10
Roundup 822 #4	Roundup, MT	9063572	21	11	2	0	1	0	0	0	14	7
Roundup 822 #6	Roundup, MT	9063573	20	9	0	0	0	0	0	0	9	11
Sparks #1	Sparks, NE	9063597	21	6	1	0	0	0	0	0	7	14
Sparks #11	Sparks, NE	9063601	21	1	0	1	0	0	0	0	2	19
Sparks #2	Sparks, NE	9063598	21	1	0	1	0	0	0	0	2	19
Sparks #8	Sparks, NE	9063599	21	13	1	0	0	0	0	0	14	7
Sparks #9	Sparks, NE	9063600	21	8	0	0	0	0	0	0	8	13
Springview #2	Springview, NE	9063589	22	7	0	0	0	0	0	0	7	15
Springview #3	Springview, NE	9063590	20	0	0	0	0	0	0	0	0	20
Springview #8	Springview, NE	9063591	17	0	0	0	0	0	0	0	0	17
Springview #9	Springview, NE	9063592	21	0	0	0	0	0	0	0	0	21
Valentine 721 #10	Valentine, NE	9063588	21	2	0	0	0	0	0	0	2	19
Valentine 721 #3	Valentine, NE	9063586	21	0	0	0	0	0	0	0	0	21
Valentine 721 #4	Valentine, NE	9063587	21	8	1	0	1	0	0	0	10	11
Wibaux 714 #1	Wibaux, MT	9063610	21	7	1	0	0	0	0	0	8	13
Grand Count			1491	473	32	55	2	1	0	0	563	928

Appendix E. Test seedling count by accession by year, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Origin	Accession Number	1989 Spring RCB Count	1989 Fall RCB Count	1990 Fall RCB Count	1991 Fall RCB Count	1992 Fall RCB Count	1993 Fall RCB Count	1994 Fall RCB Count	1995 Fall RCB Count
Ainsworth 720 #1	Ainsworth, NE	9063585	21	15	15	15	15	15	15	15
Ainsworth 720 #2 [†]	Ainsworth, NE	9063622	9	9	9	8	8	7	7	7
Ainsworth 720 #5	Ainsworth, NE	9063623	2	2	2	2	2	2	2	2
Ainsworth 720 #8	Ainsworth, NE	9063624	1	1	1	1	1	1	1	1
Ashland 11 #1	Ashland, MT	9063609	21	10	10	10	10	10	10	10
Ashland 825 #1	Ashland, MT	9063620	10	7	7	7	7	7	7	7
Ashland 825 #6	Ashland, MT	9063621	8	8	8	8	8	8	8	8
Ashland 825 #7	Ashland, MT	9063575	21	18	18	18	18	18	18	18
Big Sandy 871 #1	Big Sandy, MT	9063602	19	10	9	9	9	9	9	9
Big Sandy 871 #2	Big Sandy, MT	9063603	21	9	8	8	8	8	8	8
Big Sandy 871 #3	Big Sandy, MT	9063604	21	12	9	8	8	8	8	8
Big Sandy 871 #4	Big Sandy, MT	9063605	21	19	19	19	19	19	19	19
Big Sandy 871 #5	Big Sandy, MT	9063606	21	5	4	4	4	4	4	4
Big Sandy 871 #6	Big Sandy, MT	9063607	21	12	12	12	12	12	12	12
Big Sandy 871 #7	Big Sandy, MT	9063608	21	14	14	14	14	14	14	14
Glendive 851 #11	Glendive, MT	9063612	21	20	20	20	20	20	20	20
Glendive 851 #12	Glendive, MT	9063613	19	18	18	18	18	18	18	18
Glendive 851 #13	Glendive, MT	9063614	20	17	15	14	14	14	14	14
Helena 715 #1	Helena, MT	9063626	5	4	4	3	3	3	3	3
Helena 816 #1	Helena, MT	9063563	21	9	9	8	8	8	8	8
Helena 816 #10	Helena, MT	9063568	21	7	7	6	6	6	6	6
Helena 816 #13	Helena, MT	9063617	1	1	1	1	1	1	1	1
Helena 816 #14	Helena, MT	9063618	1	1	1	1	1	1	1	1
Helena 816 #15	Helena, MT	9063569	21	19	19	11	11	11	11	11
Helena 816 #2	Helena, MT	9063564	21	13	13	8	8	8	8	8
Helena 816 #3	Helena, MT	9063565	20	5	5	3	3	3	3	3
Helena 816 #5	Helena, MT	9063566	20	11	11	7	7	7	7	7
Helena 816 #7	Helena, MT	9063616	2	2	2	2	2	2	2	2
Helena 816 #9	Helena, MT	9063567	21	14	14	10	10	10	10	10
Jordan 81 11 #1	Jordan, MT	9063545	21	1	0	0	0	0	0	0
Jordan 81 11 #10	Jordan, MT	9063551	21	19	19	19	19	19	19	19
Jordan 81 11 #12	Jordan, MT	9063552	21	5	5	5	5	5	5	5
Jordan 81 11 #13	Jordan, MT	9063553	21	11	10	10	10	10	10	10
Jordan 81 11 #14	Jordan, MT	9063554	21	11	11	11	11	11	11	11
Jordan 81 11 #15	Jordan, MT	9063555	21	17	17	14	14	14	14	14
Jordan 81 11 #16	Jordan, MT	9063556	21	16	16	14	14	14	14	14
Jordan 81 11 #17	Jordan, MT	9063557	21	3	2	2	2	2	2	2
Jordan 81 11 #18	Jordan, MT	9063558	21	19	19	18	18	18	18	18
Jordan 81 11 #19	Jordan, MT	9063559	21	13	12	12	12	12	12	12
Jordan 81 11 #2	Jordan, MT	9063546	21	21	20	20	20	20	20	20
Jordan 81 11 #20	Jordan, MT	9063560	21	10	10	10	10	10	10	10
Jordan 81 11 #21	Jordan, MT	9063561	21	18	18	18	18	18	18	18
Jordan 81 11 #22	Jordan, MT	9063562	21	4	4	4	4	4	4	4
Jordan 81 11 #4	Jordan, MT	9063547	21	20	20	18	18	18	18	18
Jordan 81 11 #5	Jordan, MT	9063548	21	18	18	18	18	18	18	18
Jordan 81 11 #8	Jordan, MT	9063549	21	14	14	14	14	14	14	14
Jordan 81 11 #9	Jordan, MT	9063550	21	19	19	19	19	19	19	19
Kilgore #1	Kilgore, NE	9063593	17	16	16	16	16	16	16	16
Kilgore #2	Kilgore, NE	9063594	21	7	3	3	3	3	3	3
Kilgore #3	Kilgore, NE	9063595	21	16	16	15	15	15	15	15
Kilgore #4	Kilgore, NE	9063596	21	21	20	17	17	17	17	17
Lewistown 889 #1	Lewistown, MT	9063611	19	19	19	18	18	18	18	18
Rosebud 757 #13	Rosebud, SD	9063576	21	10	10	10	10	10	10	10
Rosebud 757 #14	Rosebud, SD	9063577	21	8	8	8	8	8	8	8
Rosebud 757 #16	Rosebud, SD	9063578	21	21	21	21	21	21	21	21
Rosebud 757 #22	Rosebud, SD	9063579	21	19	17	15	15	15	15	15
Rosebud 757 #26	Rosebud, SD	9063580	20	14	13	12	12	12	12	12
Rosebud 757 #32	Rosebud, SD	9063581	22	18	17	15	15	15	15	15

[†] - Accessions with less than 17 seedlings planted are noted in bold.

Appendix E. Test seedling count by accession by year, ponderosa pine provenance study, Bridger, Montana (con't).

Seed Source	Origin	Accession Number	1989	1989	1990	1991	1992	1993	1994	1995
			Spring	Fall	Fall	Fall	Fall	Fall	Fall	Fall
			RCB Count	RCB Count	RCB Count	RCB Count	RCB Count	RCB Count	RCB Count	RCB Count
Rosebud 757 #37	Rosebud, SD	9063582	21	5	4	3	3	3	3	3
Rosebud 757 #38	Rosebud, SD	9063583	21	14	14	13	13	13	13	13
Rosebud 757 #39	Rosebud, SD	9063584	21	9	7	7	7	7	7	7
Roundup 822 #1	Roundup, MT	9063574	21	20	20	19	19	19	19	19
Roundup 822 #2	Roundup, MT	9063570	21	20	20	19	19	19	19	19
Roundup 822 #3	Roundup, MT	9063571	21	13	12	10	10	10	10	10
Roundup 822 #4	Roundup, MT	9063572	21	10	8	8	7	7	7	7
Roundup 822 #6	Roundup, MT	9063573	20	11	11	11	11	11	11	11
Sparks #1	Sparks, NE	9063597	21	15	14	14	14	14	14	14
Sparks #11	Sparks, NE	9063601	21	20	20	19	19	19	19	19
Sparks #2	Sparks, NE	9063598	21	20	20	19	19	19	19	19
Sparks #8	Sparks, NE	9063599	21	8	7	7	7	7	7	7
Sparks #9	Sparks, NE	9063600	21	13	13	13	13	13	13	13
Springview #2	Springview, NE	9063589	22	15	15	15	15	15	15	15
Springview #3	Springview, NE	9063590	20	20	20	20	20	20	20	20
Springview #8	Springview, NE	9063591	17	17	17	17	17	17	17	17
Springview #9	Springview, NE	9063592	21	21	21	21	21	21	21	21
Valentine 721 #10	Valentine, NE	9063588	21	19	19	19	19	19	19	19
Valentine 721 #3	Valentine, NE	9063586	21	21	21	21	21	21	21	21
Valentine 721 #4	Valentine, NE	9063587	21	13	12	12	11	11	11	11
Wibaux 714 #1	Wibaux, MT	9063610	21	14	13	13	13	13	13	13
Grand Count			1491	1018	986	931	929	928	928	928
Number of Losses				473	32	55	2	1	0	0

Appendix F. Percent seedling survival by accession by year, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Origin	Accession Number	1989 Fall Percent Survival	1990 Fall Percent Survival	1991 Fall Percent Survival	1992 Fall Percent Survival	1993 Fall Percent Survival	1994 Fall Percent Survival	1995 Fall Percent Survival
Ainsworth 720 #1	Ainsworth, NE	9063585	71	71	71	71	71	71	71
Ainsworth 720 #2 [†]	Ainsworth, NE	9063622	100	100	89	88	78	78	78
Ainsworth 720 #5	Ainsworth, NE	9063623	100	100	100	100	100	100	100
Ainsworth 720 #8	Ainsworth, NE	9063624	100	100	100	100	100	100	100
Ashland 1 #1	Ashland, MT	9063609	48	48	48	48	48	48	48
Ashland 826 #1	Ashland, MT	9063620	70	70	70	70	70	70	70
Ashland 825 #6	Ashland, MT	9063621	100	100	100	100	100	100	100
Ashland 825 #7	Ashland, MT	9063575	86	86	86	86	86	86	86
Big Sandy 871 #1	Big Sandy, MT	9063602	53	47	47	47	47	47	47
Big Sandy 871 #2	Big Sandy, MT	9063603	43	38	38	38	38	38	38
Big Sandy 871 #3	Big Sandy, MT	9063604	57	43	38	38	38	38	38
Big Sandy 871 #4	Big Sandy, MT	9063605	90	90	90	90	90	90	90
Big Sandy 871 #5	Big Sandy, MT	9063606	24	19	19	19	19	19	19
Big Sandy 871 #6	Big Sandy, MT	9063607	57	57	57	57	57	57	57
Big Sandy 871 #7	Big Sandy, MT	9063608	67	67	67	67	67	67	67
Glendive 851 #11	Glendive, MT	9063612	95	95	95	95	95	95	95
Glendive 851 #12	Glendive, MT	9063613	95	95	95	95	95	95	95
Glendive 851 #13	Glendive, MT	9063614	85	75	70	70	70	70	70
Helena 716 #1	Helena, MT	9063626	80	80	60	60	60	60	60
Helena 816 #1	Helena, MT	9063563	43	43	38	38	38	38	38
Helena 816 #10	Helena, MT	9063568	33	33	28	28	28	28	28
Helena 816 #13	Helena, MT	9063617	100	100	100	100	100	100	100
Helena 816 #14	Helena, MT	9063618	100	100	100	100	100	100	100
Helena 816 #15	Helena, MT	9063569	90	90	52	52	52	52	52
Helena 816 #2	Helena, MT	9063564	62	62	38	38	38	38	38
Helena 816 #3	Helena, MT	9063565	25	25	15	15	15	15	15
Helena 816 #5	Helena, MT	9063566	55	55	35	35	35	35	35
Helena 816 #7	Helena, MT	9063616	100	100	100	100	100	100	100
Helena 816 #9	Helena, MT	9063567	67	67	48	48	48	48	48
Jordan 811 #1	Jordan, MT	9063545	5	0	0	0	0	0	0
Jordan 811 #10	Jordan, MT	9063551	90	90	90	90	90	90	90
Jordan 811 #12	Jordan, MT	9063552	24	24	24	24	24	24	24
Jordan 811 #13	Jordan, MT	9063553	52	48	48	48	48	48	48
Jordan 811 #14	Jordan, MT	9063554	52	52	52	52	52	52	52
Jordan 811 #15	Jordan, MT	9063555	81	81	67	67	67	67	67
Jordan 811 #16	Jordan, MT	9063556	76	76	67	67	67	67	67
Jordan 811 #17	Jordan, MT	9063557	14	9	9	9	9	9	9
Jordan 811 #18	Jordan, MT	9063558	90	90	86	86	86	86	86
Jordan 811 #19	Jordan, MT	9063559	62	57	57	57	57	57	57
Jordan 811 #2	Jordan, MT	9063546	100	95	95	95	95	95	95
Jordan 811 #20	Jordan, MT	9063560	48	48	48	48	48	48	48
Jordan 811 #21	Jordan, MT	9063561	86	86	86	86	86	86	86
Jordan 811 #22	Jordan, MT	9063562	19	19	19	19	19	19	19
Jordan 811 #4	Jordan, MT	9063547	95	95	86	86	86	86	86
Jordan 811 #5	Jordan, MT	9063548	86	86	86	86	86	86	86
Jordan 811 #8	Jordan, MT	9063549	67	67	67	67	67	67	67
Jordan 811 #9	Jordan, MT	9063550	90	90	90	90	90	90	90
Kilgore #1	Kilgore, NE	9063593	94	94	94	94	94	94	94
Kilgore #2	Kilgore, NE	9063594	33	14	14	14	14	14	14
Kilgore #3	Kilgore, NE	9063595	76	76	71	71	71	71	71
Kilgore #4	Kilgore, NE	9063596	100	95	81	81	81	81	81
Lewistown 889 #1	Lewistown, MT	9063611	100	100	95	95	95	95	95
Rosebud 757 #13	Rosebud, SD	9063576	48	48	48	48	48	48	48
Rosebud 757 #14	Rosebud, SD	9063577	38	38	38	38	38	38	38
Rosebud 757 #16	Rosebud, SD	9063578	100	100	100	100	100	100	100
Rosebud 757 #22	Rosebud, SD	9063579	90	81	71	71	71	71	71
Rosebud 757 #26	Rosebud, SD	9063580	67	62	57	57	57	57	57
Rosebud 757 #32	Rosebud, SD	9063581	82	77	68	68	68	68	68
Rosebud 757 #37	Rosebud, SD	9063582	24	19	14	14	14	14	14

[†] - Accessions with less than 17 seedlings planted are noted in bold.

Appendix F. Percent seedling survival by accession by year, ponderosa pine provenance study, Bridger, Montana (con't).

Seed Source	Origin	Accession Number	1989 Fall Percent Survival	1990 Fall Percent Survival	1991 Fall Percent Survival	1992 Fall Percent Survival	1993 Fall Percent Survival	1994 Fall Percent Survival	1995 Fall Percent Survival
Rosebud 757 #38	Rosebud, SD	9063583	67	67	62	62	62	62	62
Rosebud 757 #39	Rosebud, SD	9063584	43	33	33	33	33	33	33
Roundup 822 #1 1	Roundup, MT	9063574	95	95	90	90	90	90	90
Roundup 822 #2	Roundup, MT	9063570	95	95	90	90	90	90	90
Roundup 822 #3	Roundup, MT	9063571	62	57	48	48	48	48	48
Roundup 822 #4	Roundup, MT	9063572	48	38	38	33	33	33	33
Roundup 822 #6	Roundup, MT	9063573	55	55	55	55	55	55	55
Sparks #1	Sparks, NE	9063597	71	67	67	67	67	67	67
Sparks #1 1	Sparks, NE	9063601	95	95	90	90	90	90	90
Sparks #2	Sparks, NE	9063598	95	95	90	90	90	90	90
Sparks #8	Sparks, NE	9063599	38	33	33	33	33	33	33
Sparks #9	Sparks, NE	9063600	62	62	62	62	62	62	62
Springview #2	Springview, NE	9063589	68	68	68	68	68	68	68
Springview #3	Springview, NE	9063590	100	100	100	100	100	100	100
Springview #8	Springview, NE	9063591	100	100	100	100	100	100	100
Springview #9	Springview, NE	9063592	100	100	100	100	100	100	100
Valentine 721 #10	Valentine, NE	9063588	90	90	90	90	90	90	90
Valentine 721 #3	Valentine, NE	9063586	100	100	100	100	100	100	100
Valentine 721 #4	Valentine, NE	9063587	62	57	57	52	52	52	52
Wibaux 714 #1	Wibaux, MT	9063610	67	62	62	62	62	62	62
Grand Percent Survival			68	66	62	62	62	62	62

Appendix G. Mean plant height by accession by year, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Origin	Accession Number	1989 Preplant Height	1989 Fall Height	1990 Fall Height	1991 Fall Height	1992 Fall Height	1993 Fall Height	1994 Fall Height	1995 Fall Height
			cm	cm	cm	cm	cm	cm	cm	cm
Ainsworth 720 #11	Ainsworth, Nebraska	9063585	18.0	25.8	39.4	71.4	100.1	136.3	187.0	247.0
Ainsworth 720 #2†	Ainsworth, Nebraska	9063622	18.3	25.1	42.3	67.8	107.4	152.1	195.0	245.0
Ainsworth 720 #5	Ainsworth, Nebraska	9063623	19.0	26.0	50.5	87.0	135.0	177.5	222.6	260.0
Ainsworth 720 #8	Ainsworth, Nebraska	9063624	21.0	32.0	46.0	80.0	122.0	160.0	210.0	265.0
Ashland 1 #1	Ashland, Montana	9063609	16.8	24.4	38.1	67.5	105.8	140.1	198.0	261.0
Ashland 825 #1	Ashland, Montana	9063620	14.2	19.7	34.7	64.3	100.0	145.7	190.7	245.0
Ashland 825 #6	Ashland, Montana	9063621	18.6	23.1	33.6	64.5	103.6	147.5	199.4	265.6
Ashland 825 #7	Ashland, Montana	9063575	22.3	28.0	41.7	70.4	106.6	147.2	199.4	259.2
Big Sandy 871 #1	Big Sandy, Montana	9063602	18.9	21.6	32.6	60.8	84.8	112.2	154.4	202.2
Big Sandy 871 #2	Big Sandy, Montana	9063603	18.2	25.9	36.0	64.4	93.3	124.4	168.8	223.8
Big Sandy 871 #3	Big Sandy, Montana	9063604	14.3	17.5	25.1	42.7	65.4	86.9	124.4	169.4
Big Sandy 871 #4	Big Sandy, Montana	9063605	15.0	21.2	33.9	61.5	93.7	128.9	173.7	226.1
Big Sandy 871 #5	Big Sandy, Montana	9063606	20.1	20.6	35.3	61.8	91.0	123.8	172.5	222.5
Big Sandy 871 #6	Big Sandy, Montana	9063607	16.4	26.9	41.8	71.5	108.7	144.2	189.2	242.1
Big Sandy 871 #7	Big Sandy, Montana	9063608	20.4	29.0	39.1	67.0	101.4	136.8	184.3	237.9
Glendive 851 #11	Glendive, Montana	9063612	14.7	22.1	38.4	68.3	100.6	135.8	177.5	223.3
Glendive 851 #12	Glendive, Montana	9063613	15.9	21.4	38.6	72.5	102.3	145.8	193.1	248.1
Glendive 851 #13	Glendive, Montana	9063814	12.0	14.4	29.5	57.1	89.3	126.1	172.9	230.0
Helena 715 #1	Helena, Montana	9063626	19.4	24.0	34.3	53.0	75.7	101.7	145.0	190.0
Helena 816 #1	Helena, Montana	9063563	19.8	27.4	32.9	47.9	67.4	100.6	144.4	200.0
Helena 816 #10	Helena, Montana	9063568	19.8	25.3	37.4	67.6	87.3	118.3	160.8	215.0
Helena 816 #13	Helena, Montana	9063617	4.0	5.0	20.0	49.0	65.0	100.0	150.0	210.0
Helena 816 #14	Helena, Montana	9063618	23.0	31.0	49.0	76.0	110.0	150.0	200.0	245.0
Helena 816 #15	Helena, Montana	9063569	23.2	29.7	32.3	47.2	82.5	109.5	152.7	191.8
Helena 816 #2	Helena, Montana	9063564	16.2	19.5	26.3	43.3	68.0	93.8	136.3	191.9
Helena 816 #3	Helena, Montana	9063565	14.9	22.8	27.5	46.8	76.0	108.3	153.3	193.3
Helena 816 #5	Helena, Montana	9063566	16.1	21.3	28.1	44.0	70.0	100.0	145.7	194.3
Helena 816 #7	Helena, Montana	9063615	18.0	27.5	42.5	74.0	109.0	150.0	200.0	235.0
Helena 816 #9	Helena, Montana	9063567	18.2	23.3	31.2	50.9	79.4	110.5	153.0	195.5
Jordan 811 #1	Jordan, Montana	9063545	22.0	24.0	0.0	0.0	0.0	0.0	0.0	0.0
Jordan 811 #10	Jordan, Montana	9063551	18.9	26.2	37.3	63.3	91.8	122.1	163.2	218.2
Jordan 811 #12	Jordan, Montana	9063552	16.3	21.4	34.8	60.8	95.0	133.0	183.0	236.0
Jordan 811 #13	Jordan, Montana	9063553	17.4	24.7	40.5	65.7	96.1	131.0	175.0	235.5
Jordan 811 #14	Jordan, Montana	9063554	18.4	25.1	37.6	65.9	96.5	129.1	170.5	221.8
Jordan 811 #15	Jordan, Montana	9063555	18.8	23.1	31.9	58.4	94.5	131.4	180.0	238.2
Jordan 811 #16	Jordan, Montana	9063556	20.6	25.6	36.4	63.1	96.8	133.9	185.7	247.5
Jordan 811 #17	Jordan, Montana	9063557	15.6	22.7	40.0	75.5	107.5	152.5	200.0	257.5
Jordan 811 #18	Jordan, Montana	9063558	18.9	24.8	39.8	68.1	97.4	130.0	172.8	222.5
Jordan 811 #19	Jordan, Montana	9063559	18.1	21.1	34.6	59.6	85.8	119.2	163.3	213.8
Jordan 811 #2	Jordan, Montana	9063546	20.2	25.6	38.8	63.6	90.0	119.8	160.5	208.3
Jordan 811 #20	Jordan, Montana	9063560	16.5	18.3	30.8	59.2	86.7	120.5	165.0	218.0
Jordan 811 #21	Jordan, Montana	9063561	16.4	22.4	31.4	59.4	86.4	114.4	154.7	203.9
Jordan 811 #22	Jordan, Montana	9063562	22.8	23.3	41.3	66.3	96.8	126.3	165.0	212.5
Jordan 811 #4	Jordan, Montana	9063547	16.0	19.5	27.5	47.4	72.1	95.6	134.2	177.8
Jordan 811 #5	Jordan, Montana	9063548	16.4	20.3	34.3	61.8	93.8	127.5	167.2	223.9
Jordan 811 #8	Jordan, Montana	9063549	16.7	22.7	33.9	64.9	94.9	127.5	176.1	235.7
Jordan 811 #9	Jordan, Montana	9063550	24.0	31.8	44.8	73.4	104.6	142.1	186.1	246.8
Kilgore #1	Kilgore, Nebraska	9063593	14.7	20.1	32.5	64.5	97.8	136.9	180.6	232.5
Kilgore #2	Kilgore, Nebraska	9063594	15.9	16.9	29.7	58.3	90.7	126.7	175.0	231.7
Kilgore #3	Kilgore, Nebraska	9063595	19.3	27.6	40.7	70.0	111.1	152.7	204.7	260.3
Kilgore #4	Kilgore, Nebraska	9063596	21.6	26.6	39.5	63.8	96.8	132.6	179.7	234.7
Lewistown 889 #1	Lewistown, Montana	9063611	16.2	22.4	32.1	60.6	92.9	127.8	170.6	223.6
Rosebud 757 #13	Rosebud, S. Dakota	9063576	27.0	35.8	48.6	79.0	119.5	164.0	222.5	287.5
Rosebud 757 #14	Rosebud, S. Dakota	9063577	20.9	32.9	43.6	75.6	112.0	151.9	204.4	265.6
Rosebud 757 #16	Rosebud, S. Dakota	9063578	24.0	30.1	43.9	72.1	105.2	143.6	193.3	249.5
Rosebud 757 #22	Rosebud, S. Dakota	9063579	23.3	29.3	38.0	64.3	101.4	140.7	189.7	245.0
Rosebud 757 #26	Rosebud, S. Dakota	9063580	22.7	26.4	38.7	67.5	105.6	147.1	202.1	258.8

† - Accessions with less than 17 seedlings planted are noted in bold.

Appendix G. Mean plant height by accession by year, ponderosa pine provenance study, Bridger, Montana (con't).

Seed Source	Origin	Accession Number	1989	1989	1990	1991	1992	1993	1994	1995
			Preplant	Fall	Fall	Fall	Fall	Fall	Fall	Fall
			Height	Height	Height	Height	Height	Height	Height	Height
			cm	cm	cm	cm	cm	cm	cm	cm
Rosebud 757 #32	Rosebud, S.Dakota	9063581	24.9	32.6	41.8	69.1	104.2	148.0	200.0	261.7
Rosebud 757 #37	Rosebud, S.Dakota	9063582	23.5	30.2	32.8	60.8	105.0	143.3	195.0	256.7
Rosebud 757 #38	Rosebud, S.Dakota	9063583	20.0	26.1	37.6	66.0	99.4	135.4	185.0	243.1
Rosebud 757 #39	Rosebud, S.Dakota	9063584	13.0	20.7	35.6	62.7	98.0	138.6	188.6	254.3
Roundup 822 #11	Roundup, Montana	9063574	13.9	18.7	33.9	59.2	93.1	125.8	168.7	218.4
Roundup 822 #2	Roundup, Montana	9063570	24.3	30.7	44.3	73.4	103.5	137.9	186.3	247.6
Roundup 822 #3	Roundup, Montana	9063571	21.6	27.4	38.3	66.1	108.9	149.5	204.5	267.0
Roundup 822 #4	Roundup, Montana	9063572	16.9	20.8	38.0	67.9	102.9	147.1	196.4	257.9
Roundup 822 #6	Roundup, Montana	9063573	20.9	27.5	38.3	64.4	97.5	135.5	185.5	243.6
Sparks #1	Sparks, Nebraska	9063597	14.2	19.2	28.8	61.9	91.0	124.3	170.0	223.9
Sparks #1 ■	Sparks, Nebraska	9063601	22.7	28.7	43.1	73.9	113.1	157.1	210.3	270.0
Sparks #2	Sparks, Nebraska	9063598	23.3	29.9	42.8	74.8	113.1	151.1	206.6	267.9
Sparks #8	Sparks, Nebraska	9063599	21.2	29.9	44.5	74.9	111.3	152.9	205.0	265.0
Sparks #9	Sparks, Nebraska	9063600	18.9	28.1	41.9	77.8	118.2	162.7	218.5	283.1
Springview #2	Springview, Nebraska	9063589	19.3	26.1	38.4	72.4	109.9	148.3	200.3	261.7
Springview #3	Springview, Nebraska	9063590	22.1	29.3	43.8	76.8	112.2	148.5	195.0	250.0
Springview #8	Springview, Nebraska	9063591	18.5	25.6	42.5	73.0	109.3	146.5	195.3	250.3
Springview #9	Springview, Nebraska	9063592	24.3	32.1	44.9	75.8	110.5	146.9	195.2	250.5
Valentine 721 #10	Valentine, Nebraska	9063588	23.5	29.6	45.4	77.9	116.8	156.3	205.8	266.1
Valentine 721 #3	Valentine, Nebraska	9063586	19.8	25.2	40.6	74.0	112.1	155.0	207.4	270.7
Valentine 721 #4	Valentine, Nebraska	9063587	18.5	24.0	35.2	66.7	108.2	154.1	211.4	272.3
Wibaux 714 #1	Wibaux, Montana	9063610	16.6	20.4	32.6	57.9	88.8	126.2	176.2	233.1
Grand Mean Height			19.1	25.1	37.5	65.4	99.0	135.3	182.6	238.1
Grand Mean Growth				6.0	12.4	27.9	33.6	36.6	47.3	55.5
Grand Percentage Increase in Growth					107	125	20	9	29	17

Appendix H. Mean vigor rating by accession by year, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Origin	Accession Number	1990	1991	1992	1993	1994	1995
			Fall Vigor Rating†	Fall Vigor Rating	Fall Vigor Rating	Fall Vigor Rating	Fall Vigor Rating	Fall Vigor Rating
Ainsworth 720 #1 1	Ainsworth, Nebraska	9063585	2.1	3.7	3.7	3.4	3.8	4.3
Ainsworth 720 #2†	Ainsworth, Nebraska	9063622	1.8	3.8	2.8	2.9	3.0	4.1
Ainsworth 720 #5	Ainsworth, Nebraska	9063623	1.0	1.5	1.5	2.6	3.0	6.0
Ainsworth 720 #8	Ainsworth, Nebraska	9063624	1.0	2.0	2.0	2.0	3.0	4.0
Ashland 1 #1	Ashland, Montana	9063609	2.3	3.8	3.4	3.0	3.0	3.8
Ashland 825 #1	Ashland, Montana	9063620	2.1	4.0	3.3	2.4	3.3	4.1
Ashland 825 #6	Ashland, Montana	9063621	2.1	4.3	3.9	3.0	3.4	3.9
Ashland 825 #7	Ashland, Montana	9063575	2.0	3.8	3.4	2.8	3.4	3.7
Big Sandy 871 #1	Big Sandy, Montana	9063602	2.0	4.6	4.2	3.9	4.0	4.9
Big Sandy 871 #2	Big Sandy, Montana	9063603	2.0	4.3	4.1	3.4	3.8	4.5
Big Sandy 871 #3	Big Sandy, Montana	9063604	2.7	5.7	5.5	5.0	5.0	5.9
Big Sandy 871 #4	Big Sandy, Montana	9063605	1.9	4.4	3.9	3.5	3.9	4.6
Big Sandy 871 #5	Big Sandy, Montana	9063606	2.3	4.3	4.0	3.5	4.0	4.0
Big Sandy 871 #6	Big Sandy, Montana	9063607	1.9	3.4	3.3	3.3	3.7	4.0
Big Sandy 871 #7	Big Sandy, Montana	9063608	1.8	4.1	3.6	3.1	3.9	4.4
Glendive 851 #1 1	Glendive, Montana	9063612	2.0	3.6	3.3	3.0	3.6	4.1
Glendive 851 #12	Glendive, Montana	9063613	1.7	3.6	3.0	2.6	3.4	3.9
Glendive 851 #13	Glendive, Montana	9063614	2.4	4.6	4.1	3.4	3.9	4.3
Helena 716 #1	Helena, Montana	9063626	3.0	6.3	6.0	4.7	4.7	6.7
Helena 816 #1	Helena, Montana	9063563	3.0	5.9	5.1	4.9	5.0	5.8
Helena 816 #10	Helena, Montana	9063568	2.4	4.4	4.3	3.7	4.2	5.0
Helena 816 #13	Helena, Montana	9063617	2.0	6.0	5.0	5.0	5.0	5.0
Helena 816 #14	Helena, Montana	9063618	1.0	2.0	3.0	4.0	4.0	4.0
Helena 816 #15	Helena, Montana	9063569	4.1	6.1	4.7	4.8	5.4	5.5
Helena 816 #2	Helena, Montana	9063564	2.9	5.8	5.0	4.4	4.4	4.9
Helena 816 #3	Helena, Montana	9063565	3.8	6.0	5.0	5.0	5.3	5.7
Helena 816 #5	Helena, Montana	9063566	4.0	6.0	5.3	4.6	4.7	5.6
Helena 816 #7	Helena, Montana	9063615	2.6	3.5	3.5	3.5	4.6	5.6
Helena 816 #9	Helena, Montana	9063567	2.8	5.4	4.3	4.1	4.8	5.3
Jordan 81 1 #1	Jordan, Montana	9063545						
Jordan 81 1 #10	Jordan, Montana	9063551	2.3	4.3	3.9	3.6	3.7	4.5
Jordan 81 1 #12	Jordan, Montana	9063552	2.0	4.2	3.6	3.0	3.0	3.6
Jordan 81 1 #13	Jordan, Montana	9063553	2.5	4.2	3.9	3.4	3.5	4.4
Jordan 81 1 #14	Jordan, Montana	9063554	2.2	4.0	3.6	3.4	3.6	4.1
Jordan 81 1 #15	Jordan, Montana	9063555	2.9	4.7	3.8	3.4	3.3	4.1
Jordan 81 1 #16	Jordan, Montana	9063556	2.6	4.6	3.7	3.2	3.6	4.2
Jordan 81 1 #17	Jordan, Montana	9063557	2.0	3.5	4.0	2.5	3.5	3.5
Jordan 81 1 #18	Jordan, Montana	9063558	2.3	4.0	3.7	3.7	4.0	4.4
Jordan 81 1 #19	Jordan, Montana	9063559	2.3	4.8	4.5	3.8	4.3	5.0
Jordan 81 1 #2	Jordan, Montana	9063546	2.8	4.7	4.4	3.7	4.2	4.6
Jordan 81 1 #20	Jordan, Montana	9063560	2.4	4.8	4.1	3.4	3.7	4.2
Jordan 81 1 #21	Jordan, Montana	9063561	1.8	4.3	4.2	3.4	3.6	4.3
Jordan 81 1 #22	Jordan, Montana	9063562	2.0	4.5	3.8	3.5	3.8	4.8
Jordan 81 1 #4	Jordan, Montana	9063547	3.0	5.7	5.0	4.5	4.8	5.3
Jordan 81 1 #5	Jordan, Montana	9063548	2.3	4.7	4.2	3.7	3.8	4.6
Jordan 81 1 #8	Jordan, Montana	9063549	2.2	4.2	3.9	3.3	3.9	4.4
Jordan 81 1 #9	Jordan, Montana	9063550	2.1	3.5	3.3	2.8	3.2	3.9
Kilgore #1	Kilgore, Nebraska	9063593	2.0	3.9	3.3	2.8	3.3	4.3
Kilgore #2	Kilgore, Nebraska	9063594	2.3	5.3	4.3	3.0	3.7	3.7
Kilgore #3	Kilgore, Nebraska	9063595	2.4	3.3	2.7	2.4	2.7	3.2
Kilgore #4	Kilgore, Nebraska	9063596	3.0	4.5	3.9	3.7	3.9	4.6
Lewistown 889 #1	Lewistown, Montana	9063611	2.2	4.3	4.0	3.3	3.7	4.3
Rosebud 757 #13	Rosebud, S. Dakota	9063576	1.9	3.1	2.8	3.0	3.9	3.8
Rosebud 757 #14	Rosebud, S. Dakota	9063577	2.1	3.6	3.1	2.8	3.1	4.1
Rosebud 757 #16	Rosebud, S. Dakota	9063578	2.0	3.6	3.3	2.6	3.0	3.9
Rosebud 757 #22	Rosebud, S. Dakota	9063579	3.1	4.4	3.8	3.2	3.6	4.3

† - Accessions with less than 17 seedlings planted are noted in bold.

‡ - Rated 1-9 with 1 best, 4-5 average, 9 worst.

Appendix H. Mean vigor rating by accession by year, ponderosa provenance study, Bridger, Montana (con't).

Seed Source	Origin	Accession Number	1990	1991	1992	1993	1994	1995
			Fall Vigor Rating*	Fall Vigor Rating	Fall Vigor Rating	Fall Vigor Rating	Fall Vigor Rating	Fall Vigor Rating
Rosebud 757 #26	Rosebud, S. Dakota	9063580	2.7	4.0	3.4	2.6	3.2	3.8
Rosebud 757 #32	Rosebud, S. Dakota	9063581	2.4	4.3	3.5	3.0	3.5	4.1
Rosebud 757 #37	Rosebud, S. Dakota	9063582	2.5	4.3	3.3	3.0	3.0	3.7
Rosebud 757 #38	Rosebud, S. Dakota	9063583	2.2	4.3	3.8	3.2	3.7	4.4
Rosebud 757 #39	Rosebud, S. Dakota	9063584	2.1	4.4	3.9	3.3	3.5	3.9
Roundup 822 #1	Roundup, Montana	9063574	2.1	4.8	4.1	3.6	3.8	4.7
Roundup 822 #2	Roundup, Montana	9063570	2.2	3.8	3.6	3.2	3.5	3.9
Roundup 822 #3	Roundup, Montana	9063571	2.8	4.3	3.8	3.1	3.7	4.1
Roundup 822 #4	Roundup, Montana	9063572	2.0	4.5	3.6	2.9	3.3	4.0
Roundup 822 #6	Roundup, Montana	9063573	2.1	4.6	4.2	3.5	4.1	4.5
Sparks #1	Sparks, Nebraska	9063597	2.4	4.6	3.8	3.4	3.8	4.6
Sparks #11	Sparks, Nebraska	9063601	2.3	3.8	3.1	3.1	3.5	4.1
Sparks #2	Sparks, Nebraska	9063598	2.3	3.4	2.9	2.8	3.3	3.7
Sparks #8	Sparks, Nebraska	9063599	2.0	3.0	2.7	2.7	3.0	4.0
Sparks #9	Sparks, Nebraska	9063600	2.2	3.4	2.9	2.2	2.7	3.5
Springview #2	Springview, Nebraska	9063589	1.9	3.6	2.9	2.6	2.8	3.9
Springview #3	Springview, Nebraska	9063590	2.2	3.2	2.7	2.6	3.2	3.8
Springview #8	Springview, Nebraska	9063591	2.1	3.2	3.1	2.9	3.6	4.0
Springview #9	Springview, Nebraska	9063592	1.7	3.2	3.1	2.9	3.4	3.8
Valentine 721 #10	Valentine, Nebraska	9063588	2.2	3.5	2.9	2.9	3.5	4.1
Valentine 721 #3	Valentine, Nebraska	9063586	1.8	3.5	3.1	2.7	3.2	3.6
Valentine 721 #4	Valentine, Nebraska	9063587	2.3	3.9	3.1	2.6	3.0	3.5
Wibaux 714 #1	Wibaux, Montana	9063610	2.2	4.6	4.2	3.7	3.9	4.5
Grand Mean			2.3	4.2	3.7	3.2	3.7	4.3

* - Rated 1-9 with 1 best, 4.5 average, 9 worst.

Appendix I. Mean crown widths by accession by year, ponderosa pine provenance study, Bridger, Montana.

Seed Source	Origin	Accession Number	1993 Width N-S cm	1993 Width E-W cm	1994 Width N-S cm	1994 Width E-W cm	1995 Width N-S cm
Ainsworth 720 #11	Ainsworth, Nebraska	9063585	127.1	129.3	160.0	165.7	201.0
Ainsworth 720 #2 [†]	Ainsworth, Nebraska	9063622	147.1	141.4	178.6	180.7	217.9
Ainsworth 720 #5	Ainsworth, Nebraska	9063623	112.6	110.0	190.0	182.5	236.0
Ainsworth 720 #8	Ainsworth, Nebraska	9063624	160.0	166.0	200.0	200.0	240.0
Ashland 1 #1	Ashland, Montana	9063609	126.0	123.5	160.5	159.0	190.0
Ashland 826 #1	Ashland, Montana	9063620	116.4	120.9	146.0	149.3	176.4
Ashland 825 #6	Ashland, Montana	9063621	132.6	126.3	166.3	163.1	201.3
Ashland 825 #7	Ashland, Montana	9063575	117.8	117.2	152.2	153.1	184.4
Big Sandy 871 #1	Big Sandy, Montana	9063602	109.4	110.6	144.4	143.3	183.9
Big Sandy 871 #2	Big Sandy, Montana	9063603	120.0	123.1	154.4	156.9	193.1
Big Sandy 871 #3	Big Sandy, Montana	9063604	70.8	76.8	95.6	100.0	122.5
Big Sandy 871 #4	Big Sandy, Montana	9063605	118.7	117.9	150.8	148.7	183.9
Big Sandy 871 #5	Big Sandy, Montana	9063606	122.5	130.0	147.5	150.0	183.8
Big Sandy 871 #6	Big Sandy, Montana	9063607	128.3	128.8	163.3	160.0	200.8
Big Sandy 871 #7	Big Sandy, Montana	9063608	122.9	122.1	153.6	152.5	192.9
Glendive 851 #1	Glendive, Montana	9063612	124.8	124.8	155.0	154.8	196.0
Glendive 851 #12	Glendive, Montana	9063613	133.6	131.7	165.3	164.4	201.9
Glendive 851 #13	Glendive, Montana	9063614	109.3	112.5	140.4	143.2	172.9
Helena 716 #1	Helena, Montana	9063626	98.3	100.0	126.7	128.3	163.3
Helena 816 #1	Helena, Montana	9063563	80.5	79.4	103.8	108.1	131.9
Helena 816 #10	Helena, Montana	9063568	108.3	108.3	139.2	139.2	174.2
Helena 816 #13	Helena, Montana	9063617	96.0	100.0	116.0	140.0	170.0
Helena 816 #14	Helena, Montana	9063618	126.0	126.0	160.0	155.0	200.0
Helena 816 #15	Helena, Montana	9063569	92.4	93.7	122.7	122.7	158.2
Helena 816 #2	Helena, Montana	9063564	92.5	93.1	117.5	117.5	152.5
Helena 816 #3	Helena, Montana	9063565	93.3	88.3	125.0	116.7	145.0
Helena 816 #5	Helena, Montana	9063566	81.4	82.9	112.1	110.0	141.4
Helena 816 #7	Helena, Montana	9063616	117.1	110.0	147.6	140.0	182.5
Helena 816 #9	Helena, Montana	9063567	102.5	100.5	134.0	134.0	170.5
Jordan 811 #1	Jordan, Montana	9063545					
Jordan 811 #10	Jordan, Montana	9063551	114.5	110.1	138.2	136.6	175.8
Jordan 811 #12	Jordan, Montana	9063552	117.0	124.0	153.0	160.0	190.0
Jordan 811 #13	Jordan, Montana	9063553	125.5	129.5	163.0	169.0	204.0
Jordan 811 #14	Jordan, Montana	9063554	128.2	126.8	157.3	156.4	197.3
Jordan 811 #15	Jordan, Montana	9063555	121.1	118.9	153.6	150.7	186.8
Jordan 811 #16	Jordan, Montana	9063556	131.1	132.5	170.4	170.4	210.7
Jordan 811 #17	Jordan, Montana	9063557	130.0	130.0	165.0	160.0	207.5
Jordan 811 #18	Jordan, Montana	9063558	127.2	128.6	157.2	158.9	199.2
Jordan 811 #19	Jordan, Montana	9063559	110.4	111.7	139.6	139.2	167.9
Jordan 811 #2	Jordan, Montana	9063546	105.8	106.5	131.5	131.3	160.3
Jordan 811 #20	Jordan, Montana	9063560	113.0	111.0	145.5	145.0	179.5
Jordan 811 #21	Jordan, Montana	9063561	111.9	111.1	141.1	140.0	172.2
Jordan 811 #22	Jordan, Montana	9063562	132.5	130.0	167.5	166.3	211.3
Jordan 811 #4	Jordan, Montana	9063547	103.5	105.5	132.5	137.8	166.1
Jordan 811 #5	Jordan, Montana	9063548	116.5	115.4	150.0	148.3	189.4
Jordan 811 #8	Jordan, Montana	9063549	121.8	119.6	156.4	154.6	188.2
Jordan 811 #9	Jordan, Montana	9063550	124.5	127.9	156.3	158.9	193.2
Kilgore #1	Kilgore, Nebraska	9063593	121.9	120.6	157.2	153.8	194.1
Kilgore #2	Kilgore, Nebraska	9063594	110.0	106.7	138.3	141.7	170.0
Kilgore #3	Kilgore, Nebraska	9063595	141.7	136.3	178.7	175.7	221.0
Kilgore #4	Kilgore, Nebraska	9063596	118.6	119.9	151.2	152.6	190.0
Lewistown 889 #1	Lewistown, Montana	9063611	107.2	108.2	136.9	138.6	168.3
Rosebud 757 #13	Rosebud, S. Dakota	9063576	141.5	138.5	178.0	182.0	223.0
Rosebud 757 #14	Rosebud, S. Dakota	9063577	137.5	138.1	176.3	181.3	218.1
Rosebud 757 #16	Rosebud, S. Dakota	9063578	130.2	133.8	172.1	169.8	209.3
Rosebud 757 #22	Rosebud, S. Dakota	9063579	132.0	131.7	168.7	171.7	211.7
Rosebud 757 #26	Rosebud, S. Dakota	9063580	124.6	121.3	156.7	158.3	202.5
Rosebud 757 #32	Rosebud, S. Dakota	9063581	129.3	126.0	166.3	166.0	205.3
Rosebud 757 #37	Rosebud, S. Dakota	9063582	120.0	125.0	161.7	170.0	203.3

[†] - Accessions with less than 17 seedlings planted are noted in bold.

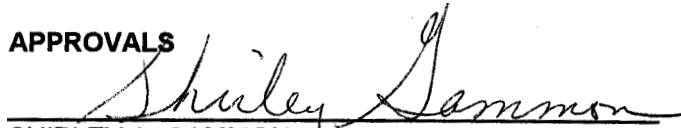
Appendix I. Mean crown widths by accession by year, ponderosa pine provenance study, Bridger, Montana (con't).

Seed Source	Origin	Accession Number	1993	1993	1994	1994	1995
			Width N-S cm	Width E-W cm	Width N-S cm	Width E-W cm	Width N-S cm
Rosebud 757 #38	Rosebud, S. Dakota	9063583	132.3	130.0	167.7	168.5	214.6
Rosebud 757 #39	Rosebud, S. Dakota	9063584	127.9	125.7	158.6	157.9	204.3
Roundup 822 #11	Roundup, Montana	9063574	115.0	115.5	141.6	144.7	176.6
Roundup 822 #2	Roundup, Montana	9063570	113.2	114.5	144.2	148.2	181.3
Roundup 822 #3	Roundup, Montana	9063571	123.5	124.0	158.0	157.5	190.5
Roundup 822 #4	Roundup, Montana	9063572	118.6	121.4	154.3	155.0	188.6
Roundup 822 #6	Roundup, Montana	9063573	116.8	118.2	150.5	152.7	188.6
Sparks #1	Sparks, Nebraska	9063597	122.9	123.9	154.3	157.9	196.4
Sparks #11	Sparks, Nebraska	9063601	142.9	141.3	179.5	181.3	224.7
Sparks #2	Sparks, Nebraska	9063598	135.5	135.8	171.8	178.4	216.3
Sparks #8	Sparks, Nebraska	9063599	146.4	158.6	185.7	202.1	234.3
Sparks #9	Sparks, Nebraska	9063600	146.5	148.1	185.8	185.8	231.2
Springview #2	Springview, Nebraska	9063589	146.7	141.3	179.7	178.7	233.7
Springview #3	Springview, Nebraska	9063590	140.3	142.2	176.0	179.8	223.8
Springview #8	Springview, Nebraska	9063591	145.9	146.2	182.6	184.1	228.8
Springview #9	Springview, Nebraska	9063592	131.7	138.8	169.5	173.6	216.4
Valentine 721 #10	Valentine, Nebraska	9063588	133.9	135.8	173.9	174.5	215.3
Valentine 721 #3	Valentine, Nebraska	9063586	139.3	137.4	176.2	174.8	217.9
Valentine 721 #4	Valentine, Nebraska	9063587	135.5	136.4	171.4	176.4	217.3
Wibaux 714 #1	Wibaux, Montana	9063610	109.6	111.5	143.8	142.3	174.6
Grand Mean			123.0	123.3	156.2	157.2	194.7

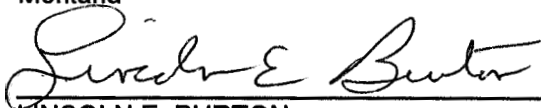
Appendix J. Mean heights of orchard selections **by** accession **by** year from **1989** through 1995, Bridger, Montana.

Seed Source	Mean	Mean	Mean Height	Mean Height	Mean Height	Mean Height	Mean Height	Mean Height
	Height	Height						
	Spring	Fall						
	1989	1989	1990	1991	1992	1993	1994	1995
	cm	cm	cm	cm	cm	cm	cm	cm
Jordan 811 #8	21.6	27.2	35.8	68.6	100.0	135.0	189.0	257.0
Jordan 811 #9	24.9	31.7	41.0	76.0	112.7	156.4	204.3	266.4
Jordan 811 #10	23.0	29.0	29.0	79.0	119.0	160.0	210.0	275.0
Jordan 811 #14	26.0	33.0	42.0	73.0	114.0	155.0	215.0	270.0
Jordan 811 #15	22.8	26.2	33.0	65.8	100.8	143.0	202.0	267.0
Jordan 811 #16	22.2	27.6	30.2	75.8	111.0	155.0	211.0	287.0
Jordan 811 #18	22.0	28.0	48.0	83.0	125.0	170.0	200.0	270.0
Roundup 822 #2	24.9	31.1	46.8	77.8	117.3	158.8	210.6	274.4
Roundup 822 #3	26.0	30.0	45.0	70.0	112.0	155.0	220.0	280.0
Ashland 825 #7	23.7	30.9	40.9	74.9	112.9	156.5	211.5	278.5
Rosebud 757 #16	24.5	31.5	44.4	78.0	112.3	158.1	215.0	278.1
Rosebud 757 #22	24.5	31.3	39.8	71.7	112.0	157.5	213.3	275.8
Rosebud 757 #26	22.5	28.0	41.0	69.7	106.2	150.8	208.3	273.3
Rosebud 757 #32	20.6	27.3	38.0	73.4	108.7	157.2	211.7	277.8
Rosebud 757 #37	28.0	35.0	52.0	89.0	138.0	185.0	240.0	305.0
Rosebud 757 #38	15.8	21.7	37.0	67.5	104.3	147.5	203.8	260.0
Rosebud 757 #39	31.0	35.0	52.0	90.0	143.0	195.0	245.0	320.0
Ainsworth 720 #11	20.2	26.7	33.8	76.2	115.0	159.2	218.3	290.0
Valentine 721 #3	19.1	24.3	39.8	74.8	115.6	157.9	212.9	280.0
Valentine 721 #4	15.5	19.0	31.0	66.0	117.5	172.5	235.0	312.5
Valentine 721 #10	23.8	29.8	49.8	94.0	146.2	195.0	251.0	324.0
Springview #2	20.3	26.6	36.3	73.6	112.0	152.0	205.5	267.5
Springview #3	22.8	31.2	42.7	80.4	118.7	160.0	212.5	276.0
Springview #8	19.4	25.4	43.8	72.2	110.2	153.0	204.0	262.0
Springview #9	24.2	31.7	40.0	76.6	117.0	161.0	217.0	278.5
Kilgore #1	17.8	24.0	37.8	76.3	117.0	161.7	208.3	266.7
Kilgore #3	22.5	28.6	43.4	76.7	120.4	165.0	220.0	278.2
Kilgore #4	19.0	25.0	47.0	97.0	146.0	200.0	265.0	345.0
Sparks #2	21.7	29.1	45.9	82.8	123.3	168.3	227.2	291.1
Sparks #8	22.0	32.0	32.0	84.0	129.0	180.0	240.0	310.0
Sparks #9	24.5	31.5	48.3	86.8	130.8	177.5	235.8	303.3
Sparks #11	24.9	31.7	47.8	84.3	123.1	168.6	225.7	287.9
Big Sandy 871 #7	25.5	33.8	43.0	74.3	108.8	147.5	198.8	261.3
Ashland #1	14.0	16.0	32.0	71.0	119.0	170.0	230.0	300.0
Glendive 851 #12	19.1	25.0	33.8	78.1	117.5	158.1	210.0	268.1
Ashland 825 #1	17.0	22.5	36.8	69.8	109.0	158.8	205.0	263.8
Ashland 825 #6	18.3	23.3	27.0	67.0	110.0	158.3	216.7	283.3
Ainsworth 720 #2	20.5	27.0	43.0	78.0	117.0	152.5	200.0	262.5
Grand Average	22.0	28.4	40.2	76.4	115.8	159.7	214.3	278.4

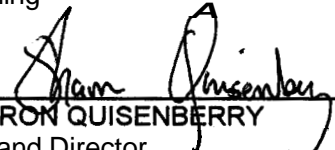
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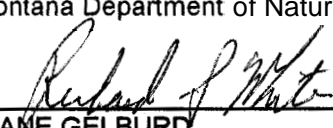
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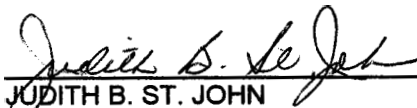
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